NICERC CURRICULA THREADS

NICERC™
AN ACADEMIC DIVISION OF THE CYBER INNOVATION CENTER
www.NICERC.org

ABOUT NICERC'S CURRICULA

NICERC works with its partners to design project-driven, application-based curricula that engages students across primary, secondary, and post-secondary grade levels. Our curricula provides school systems with a rigorous program that showcases a systems-level understanding of real-world applications of science, technology, engineering, and mathematics. Our courses provide a hands-on, context-based approach to math and science professional development while incorporating liberal arts components, which allows teachers to embed the curricula across multiple disciplines and empowers them to prepare students to become the next generation of engineers and cyber professionals.

STEM: EXPLORE, DISCOVER, APPLY

STEM: Explore, Discover, Apply (STEM EDA) engages middle school students through a series of hands-on projects that help improve their problem-solving and critical thinking skills. All projects seamlessly integrate the Engineering Design Process which allows students to creatively explore STEM through design.

This multi-grade level curricula utilizes liberal arts disciplines to provide meaning and depth to the content. Through STEM EDA, students develop invaluable skills focusing on leadership, team building, creativity, and communication.

STEM EDA's modular nature provides ultimate flexibility to schools. Teachers can implement the curricula as a standalone elective course, insert specific modules into an existing class, or provide the modules as an after-school program.

CYBER LITERACY

Cyber Literacy is a hands-on curriculum that builds a strong cyber foundation for high school students. The course introduces students to cyber by blending robotics, programming, electricity, and elements of liberal arts. Students learn about the opportunities, threats, responsibilities, and legal constraints associated with operating in cyberspace. Throughout the course, students learn the basics of electricity, programming, and networking as well as develop critical thinking skills. Cyber Literacy lays a foundation for further exploration into STEM and cyber-related topics.

CYBER LITERACY UNITS:

- *Electricity* shows the students the fundamentals of electricity from the very basic movement of electrons to practical and engaging experiments that include chemistry, circuitry, and magnetism concepts.
- *Programming* introduces students to basic coding essentials through flowcharts and simple programming languages. This unit builds the students' confidence in programming which will apply to the subsequent unit, *Robotics*.
- *Robotics* uses a Parallax® Boe-Bot® microcontroller as the platform for teaching students robotics fundamentals. Students assemble their robots to perform various functions through the implementation of sensors and application of their programming knowledge.
- *Liberal Arts* illustrates real world applications and implications of computers and the internet in our society today. Students are challenged to intensely deliberate the historical and societal context of cyber.

CYBER LITERACY II

Cyber Literacy II is a project-driven curriculum that expands a student's understanding of cyberspace through two primary topics: systems engineering and liberal arts. The Cyber Literacy II course builds upon fundamental cyber skills developed in Cyber Literacy and challenges students to go deeper into the world of cyberspace. Students will utilize a microcontroller to construct complex systems that bring together a variety of components on each build and also will realize the significant real world connections as they discuss the liberal arts/ humanities crossovers that exist with today's technologies. Many aspects of science, engineering, technology, and mathematics are discussed throughout each of the projects. Similarly, students are challenged to create flow-charts with each build as well as tossing out the wiring diagram in favor of reading schematics.

CYBER LITERACY II UNITS:

• *Systems Engineering* uses the Parallax Boe-Bot microcontroller as the platform for students to build a variety of multi-component projects, such as: a binary counter; a 4-pushbutton, hackable vault; an infrared remote-controlled Boe-Bot; a planetoid rover; and a minesweeper. Flow charts are used throughout to discuss data flow and even to touch upon pseudo-code, a programming design method of describing a simplified program, before writing the code.

• *Liberal Arts* will present discussions that dive deep into many critical aspects of our students' futures, such as: the 4th Amendment of the US Constitution, where students make connections to privacy, security, and technology; search warrants, digital media, and the requirements to obtain a search warrant; and, they will touch on cyber bullying and real world examples of the implications of cyber bullying. Students will participate in debates on national security and will complete a literary analysis of a fictional novel. Cyber Literacy II gives teachers the opportunity to collaborate with their school partners as they introduce relevant content that will support ELA instruction.

CYBER SCIENCE

Cyber Science is an innovative, project-driven course that integrates science, technology, engineering, and mathematics (STEM) disciplines with liberal arts. Cyber Science uses the Parallax® Boe-Bot® robot as a platform for teaching important cyber concepts and fundamentals. Throughout the course, students are engaged in a systems-level approach to problem-solving using robotics and computer science in the context of liberal arts. Seamlessly integrating the different disciplines provides students with a dynamic learning environment and a unique educational experience. Through Cyber Science, students are not only able to make meaningful connections between STEM and liberals arts, they also learn how to become better cyber citizens. The lessons in the course are divided into five main units: *Programming Basics, Foundations of Computer Science, Networking and Security, Artificial Intelligence*, and *Ethics and Societal Issues*. A major strength of the course is that unit components are purposefully interwoven together and provide the students with a holistic view of cyber.

CYBER SCIENCE UNITS:

• *Programming Basics (PB)* provides students with a foundation in programming. Students develop their programming skills through a progression of Boe-Bot® activities.

• *Foundations of Computer Science (CS)* allows students to build a foundation in computer science by learning about concepts such as Boolean logic, variables, flow charts, data structures, and sorting. Many of these are illustrated in the classroom using Boe-Bot® applications.

• *Networking and Security (NS)* showcases the structure of networks as well as the vulnerabilities. The need for security is heavily emphasized through man-in-the-middle attacks, cryptography, and steganography.

• *Artificial Intelligence (AI)* discusses the concepts of heuristics and using sensors to read input in order to produce a desired output. Applications of this concept are showcased through various Boe-Bot® projects that require the students to utilize sensors.

• *Ethics and Social Issues (ES)* explores the historical, ethical, and societal impacts of cyber. Students are challenged with deeper thinking through interpreting articles, writing essays, and participating in debates.

CYBER SOCIETY

Technology is advancing rapidly and connecting us in ways never before imagined. The modules in Cyber Society are designed to enable teachers to use liberal arts concepts and ideas as an approach to increase cyber awareness among high school students. This course helps contribute to the initiative of developing a better, more educated cyber workforce. The lessons within each easily customizable module improve students' critical thinking and critical reading skills as they pull information from articles and other sources. Students also practice their presentation skills as they participate in debates and group presentations. The modules include a wide variety of topics such as law, ethics, terrorism, communications, and business as they pertain to cyberspace.

CYBER SOCIETY UNITS:

- *Cyber Law* explores the differences between a criminal offense and a moral wrong, protection of intellectual property, the functions and uses of permanent electronic records, and the role of laws in addressing social challenges.
- *Cyber Ethics* examines ethical implications of extensive technology use such as conceptions of friendships, privacy, personality, and the harms inherit in new technologies.
- *Cyber Terrorism* analyzes the motivations behind, desired outcomes of, and consequences of acts of terrorism and discusses appropriate counter attacks or counter measures.
- *Cyber Communities* investigates the necessity of a networked society, crowdsourcing information, technology used in communication, virtual collaboration, and team dynamics.
- *Cyber Business* demonstrates the collection, storage, usage, and protection of data; cybersecurity attacks and threats; and technology to improve information security.

PHYSICS

The Physics curriculum provides schools with a rigorous program that showcases a systems-level understanding of science, technology, engineering, and mathematics that STEM professionals use every day. By using a project-driven approach, students become engaged early and maintain a high degree of interest and curiosity throughout the course. The course uses the Parallax® Boe-Bot® microcontroller platform, along with other hands-on activities that drive physics fundamentals in the five units: *Electricity and Magnetism*, *Work and Mechanics*, *Light and Optics, Waves and Sound*, and *Thermal Fluids and Heat Transfer*. Within each unit, the lessons are modularized to allow for maximum flexibility in the classroom. Additionally, for the convenience of schools, an approved Advanced Placement (AP) syllabus is included, and the lessons are mapped to the AP curriculum.

PHYSICS UNITS:

- *Electricity and Magnetism* allows students to develop an intuitive understanding of electrical voltage, resistance, and current by building electric circuits and using a multimeter. This unit also illustrates the coupling of electric and magnetic fields by building an electric motor and an acoustic speaker. Modules within this unit include *Introduction to the Microcontroller*, *Electricity Fundamentals*, *Electricity and Circuitry*, *Magnets and Electromagnetism*, and *Capacitance*.
- *Work and Mechanics* focuses on the more classical high school physics concepts related to gravity and motion of objects. Modules within this unit include *Gravity, Velocity, and Acceleration*; *Particle Motion*; *Forces and Simple Machines*; *Energy Conversion*; *Elastic Energy and Projectile Motion*; *Universal Gravitation*; and *Trusses*.
- *Light and Optics* contains the fundamentals of electromagnetic radiation, reflection, refraction, and optics. Projects in this section include optically counting Boe-Bot® wheel rotations and using a QTI sensor to keep a Boe-Bot® from running off a table. This unit consists of one module called *Light and Optics*.
- *Waves and Sound* explores the properties of waves, sound, and music. A main project within this unit requires students to build their own working guitar made out of materials like cardboard boxes, wire, and wood. The two modules that comprise this unit are titled *Sound* and *Music*.

List continues on next page.

• *Thermal Fluids and Heat Transfer* illustrates conversion of energy and energy transport through temperature measurement and the design of an air-powered paper rocket. The two modules that comprise this unit are titled *Thermal Fluids* and *Heat Transfer*.

ADVANCED MATH FOR ENGINEERING AND SCIENCE (AMES)

Advanced Math for Engineering and Science (AMES) is an upper level math course covering a wide range of topics that prepare students for further study in STEM fields. The overarching theme of the course is to provide a context for the content while always driving toward the fundamental mathematics concepts used by engineers and scientists. Throughout the lessons, the students engage in tasks that require researching mathematics history, comparing and contrasting parallel ideas, and communicating mathematics through formal written responses while learning, practicing, and applying the mathematics concepts covered. Concluding each unit is a cumulative project that requires the students to apply what they have learned throughout the unit. Advanced Math for Engineering and Science provides a link between the projects in the physics course and the fundamental underlying mathematics concepts of those projects.

ADVANCED MATH UNITS:

• *Two Dimensional Coordinates* explores the Cartesian and Polar coordinate systems through analytic geometry, the connections between the two systems, and projects that allow the students to apply the concepts.

• *Introduction to Linear Algebra* familiarizes students with vectors and matrices. The students explore physics and cryptography applications in these topics.

• *Three Dimensional Coordinates* expands on the two dimensional coordinates and linear algebra by adding a third dimension. Students apply the concepts through a computer aided design (CAD) project.

• *Fundamentals of Mathematics* showcases mathematical logic and set theory and the use of basic circuit design and programming.

COMPUTER SCIENCE

Computer Science is a hands-on, projects-based curriculum that utilizes a unique computing platform to engage students in an immersive exploration of the breadth of computer science. Through a puzzle-based learning approach that is strategically meshed with candid discussions of the philosophy and expectations that underlie the learning process, a foundation of problem solving and critical thinking is laid upon which the four major themes of computer science are then iteratively built as pillars. Various beams that showcase the applications of computer science are finally laid atop the pillars.

COMPUTER SCIENCE UNITS:

• *Algorithms* forms the basis for representing solutions to problems. Students focus on the development of good algorithms as solutions to interesting problems while discovering the importance of understanding problems in order to develop efficient step-by-step solutions.

• *Computer Programming* explores the reasons for using computers to execute problem solutions for us. Students learn to translate their algorithms to a language computers can understand.

• *Data Structures* explores various major data manipulation and processing structures used by computers. Students explore and utilize them as they design algorithms to solve problems.

• *Computer Architecture* provides students with the foundations of computing. Using the Raspberry Pi B v2 platform, students learn how computer hardware provides a powerful platform on which to run software.