ROBOTICS II
GRADES 11-12

EWING PUBLIC SCHOOLS
2099 Pennington Road
Ewing, NJ 08618

Board Approval Date: October 24, 2022 Michael Nitti
Produced by: EHS Technology Department Superintendent

In accordance with The Ewing Public Schools' Policy 2230, Course Guides, this curriculum has been reviewed and found to be in compliance with all policies and all affirmative action criteria.

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Course Description

Robotics is an emerging field with applications in many facets of our lives. It is important for all members of society to have an understanding of the technology that surrounds us. However, robotics is important for more than that reason. Robotics provides a unique combination of the pillars of STEM: science, technology, engineering and math. It allows students to experience a true interdisciplinary lesson while studying a cutting edge and exciting topic. Also, the aesthetics which go into the design and creation of robots allow students to experiment with an artistic side, while working through technical principals. This combination rewards participants on a plethora of different learning levels.

Students in high school develop understanding of a wide range of topics in engineering and technology that build upon similar concepts from Robotics I through more advanced content, practice, and themes. Robotics II emphasizes the interrelationships of computer aided design (CAD), iterative design, planning, prototyping, programming, strategy, machine interactions, and common themes.

There are strong connections to mathematical practices of analyzing and interpreting data. The indicators strongly reflect the many societally relevant aspects of engineering and technology with an emphasis on using computer programming and design concepts to test and refine solutions to challenges. Robotics II is offered in a block schedule, meeting daily for 87 minutes for half of the academic year (90 days). This course is divided into 7 units of study:

Unit 1 – Introduction to Robotics II
Unit 2 – Getting to Know the Speed Build
Unit 3 – Programming the Speed Build
Unit 4 – Getting to Know the V5 Clawbot
Unit 5 – Programming the V5 Clawbot
Unit 6 – Engineering Activities
Unit 7 – The Game

The course aligns to the New Jersey Core Curriculum Content Standards - Technology with a focus on students mastering both content and practices.

Resources - Digital:

- VEX EDR STEM Labs

21st Century Life and Careers

In today's global economy, students need to be lifelong learners who have the knowledge and skills to adapt to an evolving workplace and world. To address these demands, Standard 9, 21st Century Life and Careers, which includes the 12 Career Ready Practices, establishes clear guidelines for what students need to know and be able to do in order to be successful in their future careers and to achieve financial independence.

Career Ready Practices

Career ready practices describe the career ready skills that all educators in all content areas should seek to develop in their students. These are practices that have been to increase college, career, and life success. Career Ready Practices should be taught and reinforced in all career exploration and preparation programs with increasingly higher levels of complexity and expectations as a student advances through a program of study.

9.3 Career and Technical Education

This standard outlines what students should know and be able to do upon completion of a CTE Program of Study.

Architecture & Construction (AC)

- 9.3.12.AC.1: Use vocabulary, symbols and formulas common to architecture and construction.
- 9.3.12.AC.2: Use architecture and construction skills to create and manage a project.

Design/Pre-Construction (AC-DES)

- 9.3.12.AC-DES.1: Justify design solutions through the use of research documentation and analysis of data.

Science, Technology, Engineering & Mathematics (ST)

- 9.3.ST.1: Apply engineering skills in a project that requires project management, process control and quality assurance.

- 9.3.ST.6: Demonstrate technical skills needed in a chosen STEM field.

Technology Integration

8.1 Educational Technology: All students will use digital tools to access, manage, evaluate, and synthesize information in order to solve problems individually and collaborate and to create and communicate knowledge.

- 8.1.12.D.5 Analyze the capabilities and limitations of current and emerging technology resources and assess their potential to address personal, social, lifelong learning, and career needs.
- 8.1.12.F.1 Evaluate the strengths and limitations of emerging technologies and their impact on educational, career, personal and or social needs.

8.2 Technology Education, Engineering, Design, and Computational Thinking - Programming:

All students will develop an understanding of the nature and impact of technology, engineering, technological design, computational thinking and the designed world as they relate to the individual, global society, and the environment.

- 8.2.12.A.1 Propose an innovation to meet future demands supported by an analysis of the potential full costs, benefits, trade-offs and risks, related to the use of the innovation.
- 8.2.12.B.4 Investigate a technology used in a given period of history, e.g., stone age, industrial revolution or information age, and identify their impact and how they may have changed to meet human needs and wants.
- 8.2.12.C.1 Explain how open source technologies follow the design process.
- 8.2.12.C.3 Analyze a product or system for factors such as safety, reliability, economic considerations, quality control, environmental concerns, manufacturability, maintenance and repair, and human factors engineering (ergonomics).
- 8.2.12.C.4 Explain and identify interdependent systems and their functions.
- 8.2.12.C.5 Create scaled engineering drawings of products both manually and digitally with materials and measurements labeled.
- 8.2.12.D.3 Determine and use the appropriate resources (e.g., CNC (Computer Numerical Control) equipment, 3D printers, CAD software) in the design, development and creation of a technological product or system.
- 8.2.12.D.6 Synthesize data, analyze trends and draw conclusions regarding the effect of a technology on the individual, society, or the environment and publish conclusions.
- 8.2.12.E.1 Demonstrate an understanding of the problem-solving capacity of computers in our world.
- 8.2.12.E.2 Analyze the relationships between internal and external computer components.
- 8.2.12.E.3 Use a programming language to solve problems or accomplish a task (e.g., robotic functions, website designs, applications, and games).
- 8.2.12.E.4 Use appropriate terms in conversation (e.g., troubleshooting, peripherals, diagnostic software, GUI, abstraction, variables, data types and conditional statements).

ELA Integration

- NJSLS.W.11-12.6. Use technology, including the Internet, to produce, share, and update individual or shared writing products in response to ongoing feedback, including new arguments or information.
- NJSLS.W.11-12.8. Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the task, purpose, and audience; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation. (MLA or APA Style Manuals).
- NJSLS.W.11-12.9. Draw evidence from literary or informational texts to support analysis, reflection, and research.

Math Integration

- NJSLS.G-GMD.B Visualize relationships between two-dimensional and three dimensional objects
- NJSLS.G-MG.A Apply geometric concepts in modeling situations
- NJSLS.S-ID.A Summarize, represent, and interpret data on a single count or measurement variable
- NJSLS.S-IC.B Make inferences and justify conclusions from sample surveys, experiments, and observational studies

Unit 1: Introduction to Robotics II

Why Is This Unit Important?

This unit leverages the prior knowledge of robotics and engineering, and the excitement of head to head competition to inspire and engage students. Students will walk through the design and build a mobile robot to play various games. During this process they will learn key STEM principles, and robotics concepts. At the culmination of this class, they will compete head-to-head against their peers in the classroom.

Students will learn what engineers do. They will also learn what the different types of engineering are and the specific tools used by engineers during their work. This unit will build on a student's experience with an engineering notebook. This notebook will be used to document their progress throughout the semester.

Enduring Understandings:

- Students will understand what engineering is, and be able to demonstrate knowledge of what engineers do.
- Students will be able to list different types of engineering disciplines and their applications in society.
- Students will learn about the career of an artificial engineering programmer and what it takes to become one.
- Contributions of LGBTQ, disabled, minorities, and women to the field of robotics.
- Students will be able to successfully utilize the engineering design process to methodically solve problems.
- Students will demonstrate knowledge of the basic components and subsystems of a robot.
- Students will be able to list examples of robots found in the real world.
- Students will understand the fundamental subsystems and components found in the VEX EDR robots.
- Students will be able to construct robotic assemblies using the VEX EDR robots.

Essential Questions:

- What is the meaning of the term quantitative and how is it used to determine the efficacy of an idea?
- What is the engineering design process and how might it be applied to solve local or global problems?
- What is the most effective strategy for playing a game? How do we win matches?

Acquired Knowledge:

- Technology has evolved rapidly as we have entered into the information age, and this has had a major impact on how we meet human needs and wants.
- Propose an innovation to meet future demands supported by an analysis of the potential full costs, benefits, trade-offs and risks, related to the use of the innovation.
- The design process has led to various open source technologies and their availability.
- The components of a robot are the body/frame, control systems, manipulators, and drivetrain.
- Robots have a variety of modern day uses. These uses can be broken down into three major categories: Industrial Robots, Robots in Research, Robots in Education.

Acquired Skills:

- Research and present information on an existing technological product that has been repurposed for a different function.
- Analyze current technology and the resources used, to identify the trade-offs in terms of availability, cost, desirability and waste.
- Explain how open source technologies follow the design process.

Assessments:

Formative Assessments:

- Homework
- Do Nows
- Google Classroom Questions
- Exit Tickets
- Kahoot
- Group discussions/presentations:
    - Propose higher order questions
    - Have students discuss their answers with their peers in small groups

Summative Assessments:

- Design challenges
- Organize data and design ideas in an engineering notebook.

Benchmarks:

- Students will be able to use a design matrix to determine the likely efficacy of an idea.
- Students will be able to plan and conduct an evaluation of technology and resources.

Alternative Assessments:

- Modified project requirements and rubrics

Anticipatory Set:

- Daily Essential Questions

In Class Activities and Laboratory Experiences:

- Design Challenges
- Components of a Robot
- Uses of Robots
- Report on artificial programming engineer career
- Group project on famous programmers:
  - Lynn Conway
  - Henry Ford
  - Brenda Mboya

Closure and Reflection Activities:

- Engineering Notebook entries

Technology Connections:

- G-Suite for Education Tools
- VEX EDR Stem Labs

Accommodations or Modifications for Special Education, ESL or Gifted Learners:

- Accommodations or Modifications for Special Education: Teacher made worksheets, graphic organizers, study guides, and other resources
- Accommodations or Modifications for Gifted Learners: Analyze and work with case studies to connect and extend lessons to the real world

List of Applicable Performance Expectations (PE) Covered in This Unit:

- NJCCCS 8.2.12.A.2
- NJCCCS 8.2.12.A.3

Unit 2: Getting to Know the Speed Build

Why Is This Unit Important?

Students will have the opportunity to build a VEX EDR V5 Speedbot as a team. After recording their reflections on the build in their engineering notebooks, they will then learn about the importance of scale in their creations. Students will design a race course, making sure that they use precise measurements and converting units as necessary. After discussing how these skills relate in the real world by viewing examples of famous world structures that are displayed as scaled-down images, students will then prepare for the Robo Rally Challenge. For this challenge, students will combine their race courses. Once built, teams will compete against each other to see who will maneuver through the joined course the fastest.

Students will then use the robot as a means to dribble and score with a soccer ball. After experimenting with the robot, teams will use their creativity to improve the robot to perform better at dribbling and scoring. They will then compete in the Game of Robosoccer Challenge. In this activity, teams will compete against each other in a traditional game of soccer, but use the newly improved robots as their players.

Enduring Understandings:

- Precision in measurement.
- Conversion of units and scale.
- Explain what the specific components of the VEXnet System can do and how they are used to control the robot.
- Set up their microcontroller to function in both autonomous and drive controlled modes.
- Use the VEXnet system to successfully control their robot in a classroom challenge.

Essential Questions:

- How to create a race course by planning with scaled drawings?
- How does one analyze relationships between scaled measurements?
- How to convert units?
- How to understand the use of scales and proportional reasoning?
- How to assemble and then modify a robot to complete a specific task?
- How does one construct and arrange ideas in an engineering notebook?
- How to identify the criteria and constraints of the solution for their design problem by considering environmental constraints?
- How might one understand the design features that need to be considered when designing an attachment to a robot?

Acquired Knowledge:

- Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.
- "Electrical energy" may mean energy stored in a battery or energy transmitted by electric currents.
- Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them.

Acquired Skills:

- Mathematical and computational thinking in 9-12 builds on K-8 experiences and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions.
- Use mathematical models and/or computer simulations to predict the effects of a design solution on systems and/or the interactions between systems.
- Asking questions and defining problems in 9–12 builds on K–8 experiences and progresses to formulating, refining, and evaluating empirically testable questions and design problems using models and simulations.
- Analyze complex real-world problems by specifying criteria and constraints for successful solutions.
- Systems can be designed to cause a desired effect.
- When investigating or describing a system, the boundaries and initial conditions of the system need to be defined.

Assessments:

Formative Assessments:

- Do Nows
- Google Classroom Questions
- Exit Tickets
- Group discussions/presentations:
    - Propose higher order questions
    - Present information to students and ask a question
    - Have students discuss their answers with their peers at their table and discuss together as a group

Summative Assessments:

- Design challenges
- Create the V5 Speedbot
- Organize data and design ideas in an engineering notebook.

Benchmarks:

- Unit conversion with conversion factors.
- Make changes to a design or a build to improve and enhance it.

Alternative Assessments:

- Modified project requirements and rubrics

Anticipatory Set:

- Daily Essential Questions

In Class Activities and Laboratory Experiences:

- Robo Rally
- Robosoccer

Closure and Reflection Activities:

- Engineering Notebook entries

Technology Connections:

- G-Suite for Education Tools
- VEX EDR Stem Labs

Accommodations or Modifications for Special Education, ESL or Gifted Learners:

- Accommodations or Modifications for Special Education: Teacher made worksheets, graphic organizers, study guides, and other resources
- Accommodations or Modifications for Gifted Learners: Analyze and work with case studies to connect and extend lessons to the real world

List of Applicable Indicators and Performance Expectations (PE) Covered in This Unit:

- NJCCCS 8.2.12.C.1
- NJCCCS 8.2.12.C.4
- NJCCCS 8.2.12.C.5
- HS-PS2-3
- HS-ETS1-2
- HS-ETS1-3

Unit 3: Programming the Speed Build

Why Is This Unit Important?

Students will have the opportunity to build the VEX EDR Speedbot. After recording their reflections on the build in their engineering notebooks, they will be introduced to behavior-based programming, and complete a series of activities that will teach them how to drive forward or in reverse, turn right or left and wait in the Play section of this STEM Lab. They will then work as a team or individually to design, develop, and iterate a project the robot will follow to make deliveries in the Automated Challenge.

Students will then learn about programming their robot forward and backward using either graphical or text code. Students will explain the importance of momentum and momentum transfer and discuss examples in daily life. Students will construct a bowling lane in the classroom and work with their team to design a project that will use momentum transfer to knock down the pins in the Strike Challenge. Teams will compete against each other to see which team will be "Top of the Lanes."

Enduring Understandings:

- Behavior-based programming is a set of behaviors that independently work to accomplish their tasks, but together allow the robot to accomplish larger goals.
- Programming is the process of using coding to tell a robot how to perform a task.
- Pseudocode is an outline of a project that is written in plain language.
- Momentum is the quantity of motion of a moving body, measured as a product of its mass and velocity.
- Momentum transfer is the amount of momentum that one particle gives to another particle.

Essential Questions:

- How to apply building directions to create a robot to complete a specific task?
- How does one decompose problems into smaller components through systematic analysis, using constructs such as procedures, modules, and/or objects?
- How does one differentiate between the movements by the robot to drive forward, drive in reverse, turn left, turn right, and wait?
- How to identify the positive effects robotics has had on the medical field?
- How to apply building directions to create a robot that will complete a specific task?
- How to analyze directions to configure and program a robot to complete a series of tasks?
- How can one differentiate between the movements by the robot to drive forward and in reverse?
- How could one explain how the momentum of an object before a collision can predict the movement of an object after a collision?

Acquired Knowledge:

- Analyze the relationships between internal and external computer components.
- Use a block and text code for programming to solve problems or accomplish a task for robotics functions.
- Analyze a system for safety, reliability, maintenance and repair, and engineering.
- Explain and identify interdependent systems and their functions.
- Both physical models and computers can be used in various ways to aid in the engineering design process. Computers are useful for a variety of purposes, such as running simulations to test different ways of solving a problem or to see which one is most efficient or economical; and in making a persuasive presentation to a client about how a given design will meet his or her needs.

Acquired Skills:

- Create scaled engineering drawings of products both manually and digitally with materials and measurements labeled.
- Demonstrate an understanding of the problem-solving capacity of computers in our world.
- Use a programming language to solve problems or accomplish a task (e.g., robotic functions, website designs, applications, and games).
- Use appropriate terms in conversation (e.g., troubleshooting, peripherals, diagnostic software, GUI, abstraction, variables, data types and conditional statements).
- Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions—including energy, matter, and information flows— within and between systems at different scales.

Assessments:

Formative Assessments:

- Do Nows
- Google Classroom Questions
- Exit Tickets
- Group discussions/presentations:
  - Propose higher order questions
  - Present information to students and ask a question
  - Have students discuss their answers with their peers

Summative Assessments:

- Design challenges
- Create the V5 Speedbot
- Organize data and design ideas in an engineering notebook.
- Automated Challenge

Benchmarks:

- Students will be able to make unit conversion with conversion factors.
- Students will be able to make changes to a design or a build to improve and enhance it.

Alternative Assessments:

- Modified project requirements and rubrics

Suggested Labs/Activities:

- STEM Labs

Anticipatory Set:

- Daily Essential Questions

In Class Activities and Laboratory Experiences:

- Medbot
- Momentum Alley

Closure and Reflection Activities:

- Engineering Notebook entries

Technology Connections:

- G-Suite for Education Tools
- VEX EDR STEM Labs
- VEXcode V5 Blocks - v1.0
- VEXcode V5 Text - v1.0.1

Accommodations or Modifications for Special Education, ESL or Gifted Learners:

- Accommodations or Modifications for Special Education: Teacher made worksheets, graphic organizers, study guides, and other resources
- Accommodations or Modifications for Gifted Learners: Analyze and work with case studies to connect and extend lessons to the real world

List of Applicable Indicators and Performance Expectations (PE) Covered in This Unit:

- NJCCCS 8.2.12.C.4
- NJCCCS 8.2.12.D.6
- HS-ETS1-2
- HS-ETS1-3
- HS-PS2.A
- HS-PS2-1
- HS-PS2-3

Unit 4: The Clawbot

Why Is This Unit Important?

Students will have the opportunity to build a VEX EDR V5 Clawbot as a team. After recording their reflections on the build in their engineering notebooks, they will then use the robot as an artistic tool to draw objects. Teams will then use their creativity to improve the build and continue to work together to complete the hands-on "It's a Draw" challenge. In this activity, teams will compete against each other in a drawing challenge using preprinted picture cards. Students will be introduced to many new concepts that will make connections to the world around them in this unit. They will explore how robotics and new technology influences the creation of works in the field of art. Students will be introduced to robots that create art through precise movements determined by either remote control or programs developed by artists in the field. They will also work as a team to find strategies that will lead to success in meeting their goal. Finally, they will need to create a plan with their team, follow it, and then reflect on the outcomes.

Enduring Understandings:

- Develop an understanding of the relationships among technologies and the connections between technology and other fields of study.
- Artificial intelligence is the comprehension and capability demonstrated by machines, in contrast to the natural intellect displayed by humans.
- Creative process is the generating new ideas, making the connection between those ideas and producing an artifact or work of art based on those ideas.
- Being exact or strictly defined and fixed is essential for precision.
- Create and evaluate strategies and plans for manipulating objects.
- Apply the formula for acceleration to precisely run testing.
- Apply center of gravity concepts.

Essential Questions:

- How does one apply building directions to create a robot to complete a specific task?
- How are illustrations created to describe specific technological terminology?
- How are analyzing connections between text and real life objects/shapes essential in the development of a technology?
- How does motion affect the stability of objects?

Acquired Knowledge:

- Systems, which are the building blocks of technology, are embedded within larger technological, social, and environmental systems.
- The stability of a technological system is influenced by all of the components in the system, especially those in the feedback loop.
- Requirements involve the identification of the criteria and constraints of a product or system and the determination of how they affect the final design and development.
- Optimization is an ongoing process or methodology of designing or making a product and is dependent on criteria and constraints.
- Develop an innovative solution to a real world problem or issue in collaboration with peers and experts, and present ideas for feedback through social media or in an online community.
- Synthesize data, analyze trends and draw conclusions regarding the effect of a technology on the individual, society, or the environment and publish conclusions.
- Technology transfer occurs when a new user applies an existing innovation developed for one purpose in a different function.
- Knowledge gained from other fields of study has a direct effect on the development of technological products and systems.

Acquired Skills:

- Management is the process of planning, organizing, and controlling work.
- Quality control is a planned process to ensure that a product, service, or system meets established criteria.
- Ask and/or evaluate questions that challenge the premise(s) of an argument, the interpretation of a data set, or the suitability of the design.
- Manipulate variables and collect data about a complex model of a proposed process or system to identify failure points or improve performance relative to criteria for success or other variables.
- Compare and contrast various types of data sets (e.g., self-generated, archival) to examine consistency of measurements and observations.
- Evaluate the impact of new data on a working explanation and/or model of a proposed process or system.
- Analyze data to identify design features or characteristics of the components of a proposed process or system to optimize it relative to criteria for success.

Assessments:

Formative Assessments:

- Homework
- Do Nows
- Google Classroom Questions
- Exit Tickets
- Group discussions/presentations:
  - Propose higher order questions
  - Present information to students and ask a question
  - Have students discuss their answers with their peers

Summative Assessments:

- Create and program V5 Clawbot
- Design challenges
- Organize data and design ideas in an engineering notebook
- Automated challenges

Benchmarks:

- Students will be able to create illustrations to describe specific vocabulary words.
- Students will be able to analyze connections between text and real life objects/shapes.
- Students will be able to create and evaluate strategies and plans for winning the race.
- Students will be able to apply center of gravity concepts.

Alternative Assessments:

- Modified project requirements and rubrics

Suggested Labs/Activities:

- STEM Labs

Anticipatory Set:

- Daily Essential Questions

In Class Activities and Laboratory Experiences:

- It's A Draw!
- Gravity Rush

Closure and Reflection Activities:

- Engineering Notebook entries

Technology Connections:

- G-Suite for Education Tools
- VEX EDR STEM Labs
- VEXcode V5 Blocks - v1.0
- VEXcode V5 Text - v1.0.1

Accommodations or Modifications for Special Education, ESL or Gifted Learners:

- Accommodations or Modifications for Special Education: Teacher made worksheets, graphic organizers, study guides, and other resources
- Accommodations or Modifications for Gifted Learners: Analyze and work with case studies to connect and extend lessons to the real world

List of Applicable Indicators and Performance Expectations (PE) Covered in This Unit:

- NJCCCS 8.2.12.C.1
- NJCCCS 8.2.12.C.4
- NJCCCS 8.2.12.D.3
- HS-ETS1-2
- HS-ETS1-3

Unit 5: Programming the Clawbot

Why Is This Unit Important?

Students will have the opportunity to build the VEX EDR V5 Clawbot. After recording their reflections on the build in their engineering notebooks, they will review behavior-based programming such as driving forward or in reverse and turning left or right. Students will complete a series of activities that will teach them how to open and close the claw as well as lift and lower the Robot Arm in the Play section of this STEM Lab. Students will also explore range of motion using this attachment in that section. Students will discuss robotics precision in performing tasks before they prepare for the Package Dash Challenge. They will then work as a team to design, develop, and iterate a project the robot will follow to complete a series of commands to move packages in a warehouse.

Enduring Understandings:

- Behavior-based Programming A set of behaviors that independently work to accomplish their tasks, but together allow the robot to accomplish larger goals.
- Simple Behaviors A simple, yet significant task.
- Complex Behaviors A combination of different types of behaviors.
- Programming The process of using blocks to tell a robot how to perform a task.
- Pseudocode an outline of a project that is written in plain language. Engineers often create pseudocode before they begin programming.
- Range of Motion How far an object can rotate or slide before hitting some sort of limit.
- Engineering Notebook A type of journal that the students will use to record their designs, ideas, and reflections.
- Explain and use loops to create a project with repeated movements.
- Create a project that follows specific student created pseudocode that will direct their robot to dance.
- Evaluate the need for an if then else block and use it appropriately in a project.
- Evaluate and refine computational artifacts to make them more usable and accessible.
- Create projects that include sequences, events, loops, and conditionals.
- Design and iteratively develop programs that combine control structures, including nested loops and compound conditionals.
- Pair the Controller to a VEX V5 Brain.
- Download the correct project template.
- Explain and use loops to create a project that programs the controller and continuously checks if the buttons/joysticks are being pressed/moved.
- Create event based projects.
- Explore programming blocks used to program the Controller using the Tank Drive and Clawbot Control example projects and test student created projects.

Essential Questions:

- How does one apply building directions to create a robot to complete a specific task?
- How does one decompose problems into smaller components through systematic analysis, using constructs such as procedures, modules, and/or objects?
- How might one differentiate between the commands Drive Forward and Drive in Reverse, Turn Left and Turn Right, Arm Up and Arm Down, Open Claw and Close Claw?
- How might one utilize the Arm Up and Arm Down, Open Claw and Close Claw commands in a project-based activity?
- How could one explain why advances in robotic development is leading to more precise movements?

Acquired Knowledge:

- Explain and identify interdependent systems and their functions.
- New products and systems can be developed to solve problems or to help do things that could not be done without the help of technology.
- Throughout history, new technologies have resulted from the demands, values and interests of individuals, businesses, industries and societies.
- Modeling, testing, evaluating, and modifying are used to transform ideas into practical solutions.
- Demonstrate an understanding of the problem-solving capacity of computers in our world.

Acquired Skills:

- Explain and identify interdependent systems and their functions.
- Specify criteria and constraints for the design.
- Ask and/or evaluate questions that challenge the premise(s) of an argument, the interpretation of a data set, or the suitability of the design.
- Develop a complex model that allows for manipulation and testing of a proposed process or system.
- Analyze data to identify design features or characteristics of the components of a proposed process or system to optimize it relative to criteria for success.

Assessments:

Formative Assessments:

- Do Nows
- Google Classroom Questions
- Exit Tickets
- Group discussions/presentations:
  - Propose higher order questions
  - Present information to students and ask a question
  - Have students discuss their answers with their peers

Summative Assessments:

- Modify and program V5 Clawbot
- Design challenges
- Organize data and design ideas in an engineering notebook
- Automated challenges

Benchmarks:

- Students will be able to differentiate between the commands Drive Forward and Drive in Reverse, Turn Left and Turn Right, Arm Up and Arm Down, Open Claw and Close Claw.
- Students will be able to utilize the Arm Up and Arm Down, Open Claw and Close Claw commands in a project-based activity.
- Students will be able to explain why advances in robotic development is leading to more precise movements.
- Students will be able to explain and use loops to create a project with repeated movements.
- Students will be able to create a project that follows specific student created pseudocode that will direct their robot to dance.
- Students will be able to evaluate the need for an if then else block and use it appropriately in a project.

Alternative Assessments:

- Modified project requirements and rubrics

Suggested Labs/Activities:

- STEM Labs

Anticipatory Set:

- Daily Essential Questions

In Class Activities and Laboratory Experiences:

- Speedy Delivery
- Loop, there it is!
- To Do or Not to Do

Closure and Reflection Activities:

- Engineering Notebook entries

Technology Connections:

- G-Suite for Education Tools
- VEX EDR STEM Labs
- VEXcode V5 Blocks - v1.0
- VEXcode V5 Text - v1.0.1

Accommodations or Modifications for Special Education, ESL or Gifted Learners:

- Accommodations or Modifications for Special Education: Teacher made worksheets, graphic organizers, study guides, and other resources
- Accommodations or Modifications for Gifted Learners: Analyze and work with case studies to connect and extend lessons to the real world

List of Applicable Performance Expectations (PE) Covered in This Unit:

- NJCCCS 8.2.12.E.1
- NJCCCS 8.2.12.E.3
- NJCCCS 8.2.12.E.4
- HS-ETS1-2

Unit 6: Engineering Activities

Why Is This Unit Important?

Students will have the opportunity to build a custom device that meets the needs of a faux company's request and based upon their request for proposal. As part of a team, students will use collaboration and the iterative process to develop a solution and record design elements and reflections in their engineering notebooks. They will continually iterate on the design until the best possible solution is fulfilled by the team.

Students will then have the opportunity to build the V5 GearBox. After recording their reflections on the build, they will experiment with the V5 GearBox and follow a procedure that explains the mechanical advantages gained by creating compound gear ratios. Students will gain an understanding of how gear trains, when properly meshed together, can increase a machine's speed or torque output.

Enduring Understandings:

- Iterative design is the process of repeatedly testing, evaluating, and redesigning a solution until the best possible solution is achieved.
- Pseudocode is an outline of a program that is written in plain language. Engineers often create pseudocode before they begin coding.
- Manipulators are components that provide the robot with the ability to interact with its environment.
- Accumulators are designed to pick up a large number of similar objects.
- Mechanical advantage is the calculation of how much faster and easier a machine makes your work. It compares the output force a mechanism or machine gives you to the input force that is applied to that mechanism or machine to get it to work.
- Transmission is transference of force between machines or mechanisms, often with changes of torque and speed.
- Speed describes a change in position with time, or more simply put, how far an object will travel over a given period of time. This measure is given in units of distance per time, such as miles per hour or feet per second.
- Torque is described by the magnitude of the force multiplied by the distance it is from the center of rotation. Torque is measured in units of force times distance, such as inch-pounds or newton-meters.
- There are many different types of gears, and they are found very commonly in the world.
- Gear ratio is the relationship between the numbers of teeth on two meshing gears used to transmit motion. It reflects the change in mechanical advantage resulting from the gears.

Essential Questions:

- How does one compose a Request for Proposal?
- How could one design a solution to a proposed problem in a challenge?
- How might one evaluate the best build to complete a designated task?
- How does one construct a build to complete the designated task?
- How could one distinguish between the different types of manipulators and accumulators?
- How is torque and/or speed advantages created in designs?
- How might one analyze situations to know what type of gear ratio is needed in a design?
- How could one apply concepts of torque and speed advantages to understand new devices?
- How would one design and create devices with mechanical advantages?

Acquired Knowledge:

- Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them.
- When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts.
- Criteria may need to be broken down into simpler ones that can be approached systematically, and decisions about the priority of certain criteria over others (trade-offs) may be needed.

Acquired Skills:

- Modeling in 9-12 builds on K-8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed world(s).
- Develop a model based on evidence to illustrate the relationships between systems or between components of a system.
- Use a model to provide mechanistic accounts of phenomena.
- Asking questions and defining problems in 9–12 builds on K–8 experiences and progresses to formulating, refining, and evaluating empirically testable questions and design problems using models and simulations.
- Analyze complex real-world problems by specifying criteria and constraints for successful solutions.
- Mathematical and computational thinking in 9-12 builds on K-8 experiences and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions.

- Use mathematical models and/or computer simulations to predict the effects of a design solution on systems and/or the interactions between systems.
- Modeling in 9-12 builds on K-8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed world(s).
- Use a model to provide mechanistic accounts of phenomena.
- Analyzing data in 9-12 builds on K-8 experiences and progresses to introducing more detailed statistical analysis, the comparison of data sets for consistency, and the use of models to generate and analyze data.
- Analyze data using computational models in order to make valid and reliable scientific claims.

Assessments:

Formative Assessments:

- Homework
- Do Nows
- Google Classroom Questions
- Exit Tickets
- Group discussions/presentations:
    - Propose higher order questions
    - Present information to students and ask a question
    - Have students discuss their answers with their peers

Summative Assessments:

- Modify and program V5 Clawbot
- Design challenges
- Organize data and design ideas in an engineering notebook
- Automated challenges

Benchmarks:

- Students will be able to compose a Request for Proposal.
- Students will be able to distinguish between the different types of manipulators and accumulators.
- Students will be able to analyze situations to know what type of gear ratio is needed in a design.
- Students will be able to understand how to design and create devices with mechanical advantages.
- Students will be able to identify the criteria and constraints of the solution for their design problem by considering lighting constraints.

Alternative Assessments:

- Modified project requirements and rubrics

Suggested Labs/Activities:

- STEM Labs

Anticipatory Set:

- Daily Essential Questions

In Class Activities and Laboratory Experiences:

- Design by Request
- Mechanical Advantage
- Vision Sensor

Closure and Reflection Activities:

- Engineering Notebook entries

Technology Connections:

- G-Suite for Education Tools
- VEX EDR STEM Labs
- VEXcode V5 Blocks - v1.0
- VEXcode V5 Text - v1.0.1

Accommodations or Modifications for Special Education, ESL or Gifted Learners:

- Accommodations or Modifications for Special Education: Teacher made worksheets, graphic organizers, study guides, and other resources
- Accommodations or Modifications for Gifted Learners: Analyze and work with case studies to connect and extend lessons to the real world

List of Applicable Performance Expectations (PE) Covered in This Unit:

- HS-ETS1-1
- HS-ETS1-2
- HS-ETS1-3
- HS-PS2-1
- HS-PS2-2

Unit 7: The Game

Why Is This Unit Important?

Students will be presented with a game. They will split into teams and then spend the rest of the semester designing a robot which can play this game head-to-head against the robots built by their classmates. Students will have the opportunity to develop strategies and design robots to succeed at completing various tasks in a competition environment. The game provides a challenge for designers of all experience levels, and should result in exciting match play. The competition will incorporate programming, design, mechanical engineering, mathematics and physics concepts. Students will work together to determine how to best complete the tasks necessary to score the most points while working within the constraints of the game manual and time limitations. The unit provides students with real world conditions and the tools and skills to succeed. This robot build will follow the engineering design process discussed in earlier units.

Enduring Understandings:

- Explain how the process of strategic design works.
- Understand that without Strategic Design chances of success would not be very high.
- Defining objectives to select game robot design strategy.
- Cost-benefit is a comparison between the level of task difficulty and the benefit gained from successfully completing the task.

Essential Questions:

- How does one define success in robotics design?
- How does one determine the difficulty of performing a task?
- Does the task require a specific mechanism to complete?
- How does one avoid making incorrect assessments of cost and benefit?

Acquired Knowledge:

- Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them.
- When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts.
- Criteria may need to be broken down into simpler ones that can be approached systematically, and decisions about the priority of certain criteria over others (trade-offs) may be needed.
- The interconnectedness of the game analysis, the design process, and the development of prioritizing based on the cost benefit analysis are the characteristics of integration of STEM topics.

Acquired Skills:

- Analyze complex real-world problems by specifying criteria and constraints for successful solutions.
- Use mathematical models and/or computer simulations to predict the effects of a design solution on systems and/or the interactions between systems.
- Use a programming language to solve problems or accomplish a task (e.g., robotic functions, website designs, applications, and games).
- Explain and identify interdependent systems and their functions.

Assessments:

Formative Assessments:

- Homework
- Do Nows
- Google Classroom Questions
- Exit Tickets
- Group discussions/presentations:
  - Propose higher order questions
  - Present information to students and ask a question
  - Have students discuss their answers with their peers

Summative Assessments:

- Design, construct, modify and program V5 robot
- Game challenge
- Organize data and design ideas in an engineering notebook
- Automated challenges

Benchmarks:

- Students will be able to explain how the process of strategic design works.
- Students will be able to demonstrate the use of defining objectives to select game objectives.
- Students will be able to create a cost – benefit analysis to demonstrate the strengths of different tasks.

Alternative Assessments:

- Modified project requirements and rubrics

Suggested Labs/Activities:

- VEX EDR Game

Anticipatory Set:

- Daily Essential Question

In Class Activities and Laboratory Experiences:

- Swept Away

Closure and Reflection Activities:

- Engineering Notebook entries

Technology Connections:

- G-Suite for Education Tools
- VEX EDR STEM Labs
- VEXcode V5 Blocks - v1.0
- VEXcode V5 Text - v1.0.1

Accommodations or Modifications for Special Education, ESL or Gifted Learners:

- Accommodations or Modifications for Special Education: Teacher made worksheets, graphic organizers, study guides, and other resources
- Accommodations or Modifications for Gifted Learners: Analyze and work with case studies to connect and extend lessons to the real world

List of Applicable Performance Expectations (PE) Covered in This Unit:

- HS-ETS1-1
- HS-ETS1-2
- HS-ETS1-3
- HS-PS2-1
- HS-PS2-2

Sample Standards Integration

<u>21st Century Skills & Career Readiness Practices</u> 9.3.12.AC.1: Use vocabulary, symbols and formulas common to architecture and construction. 9.3.12.AC.2: Use architecture and construction skills to create and manage a project. 9.3.12.AC-DES.1: Justify design solutions through the use of research documentation and analysis of data. 9.3.ST.6: Demonstrate technical skills needed in a chosen STEM field. For example, in Unit 7, students will work collaboratively to build a project where they apply their understanding of robotics to design, test, and modify a V5 Clawbot designed to meet specified challenges.
8.1 Educational Technology All students will use digital tools to access, manage, evaluate, and synthesize information in order to solve problems individually and collaborate and create and communicate knowledge. • 8.1.12.B.2 Apply previous content knowledge by creating and piloting a digital learning game or tutorial. • 8.1.12.D.5 Analyze the capabilities and limitations of current and emerging technology resources and assess their potential to address personal, social, lifelong learning, and career needs. • 8.1.12.F.1 Evaluate the strengths and limitations of emerging technologies and their impact on educational, career, personal and or social needs. **8.2 Educational Technology** All students will develop an understanding of the nature and impact of technology, engineering, technological design, computational thinking and the designed world as they relate to the individual, global society, and the environment. • 8.2.12.A.1 Propose an innovation to meet future demands supported by an analysis of the potential full costs, benefits, trade-offs and risks, related to the use of the innovation. • 8.2.12.B.4 Investigate a technology used in a given period of history, e.g., stone age, industrial revolution or information age, and identify their impact and how they may have changed to meet human needs and wants. • 8.2.12.C.1 Explain how open source technologies follow the design process. • 8.2.12.C.3 Analyze a product or system for factors such as safety, reliability, economic considerations, quality control, environmental

concerns, manufacturability, maintenance and repair, and human factors engineering (ergonomics).

- 8.2.12.C.4 Explain and identify interdependent systems and their functions.
- 8.2.12.C.5 Create scaled engineering drawings of products both manually and digitally with materials and measurements labeled.
- 8.2.12.D.3 Determine and use the appropriate resources (e.g., CNC (Computer Numerical Control) equipment, 3D printers, CAD software) in the design, development and creation of a technological product or system.
- 8.2.12.D.6 Synthesize data, analyze trends and draw conclusions regarding the effect of a technology on the individual, society, or the environment and publish conclusions.
- 8.2.12.E.1 Demonstrate an understanding of the problem-solving capacity of computers in our world.
- 8.2.12.E.2 Analyze the relationships between internal and external computer components.
- 8.2.12.E.3 Use a programming language to solve problems or accomplish a task (e.g., robotic functions, website designs, applications, and games).
- 8.2.12.E.4 Use appropriate terms in conversation (e.g., troubleshooting, peripherals, diagnostic software, GUI, abstraction, variables, data types and conditional statements).

These standards are met in all units. For example in Unit 5, students will work collaboratively to build a project where they apply their understanding of robotics to program a V5 Clawbot designed to meet specified challenges.

<u>Interdisciplinary Connections</u>

ELA

NJSLS.W.11-12.6. Use technology, including the Internet, to produce, share, and update individual or shared writing products in response to ongoing feedback, including new arguments or information.

NJSLS.W.11-12.8. Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the task, purpose, and audience; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation. (MLA or APA Style Manuals).

NJSLS.W.11-12.9. Draw evidence from literary or informational texts to support analysis, reflection, and research.

For example, in Unit 1, students will do their career report on artificial intelligence programmers.

Math

NJSLS.G-CO.D Make geometric constructions

NJSLS.G-GMD.B Visualize relationships between two-dimensional and three dimensional objects

NJSLS.G-MG.A Apply geometric concepts in modeling situations

NJSLS.S-ID.A Summarize, represent, and interpret data on a single count or measurement variable

NJSLS.S-IC.B Make inferences and justify conclusions from sample surveys, experiments, and observational studies

For example, in Unit 3, students will work collaboratively to program, calculate, collect data, and modify a V5 Speedbot.

C.18A:35-4.35 History of disabled and LGBTQ+ persons included in middle and high school curriculum.

A board of education shall include instruction on the political, economic, and social contributions of persons with disabilities and lesbian, gay, bisexual, and transgender people, in an appropriate place in the curriculum of middle school and high school students as part of the district's implementation of the New Jersey Student Learning Standards.

In unit 1, students explore Contributions of LGBTQ, disabled, minorities, and women to the field of robotics, such as:

- Lynn Conway
- Henry Ford
- Brenda Mboya