Robotics 1 G9-12

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Course Description

Robotics I is an introduction to working with computer-controlled devices and software development. Students use the engineering design process to create prototypes, and to test, analyze, and improve designs. The focus is on basic robot construction and programming for robotic control. This is a project-based environment that requires students to build prototypes or use simulation software to test designs. Integrating sensors for closed feedback loops and automated decision making is emphasized. Students develop critical thinking and communication skills by analyzing and presenting results using Google tools.

This course is designed to introduce students to the basics of robot design and programming. The class will cover the following topics:

1. Technology & Robotics
   ○ Students will study how technology has changed through the ages, focusing on the development use of robotics.
2. Electricity & Mechanics
   ○ Study of electricity, electronics, and mechanical systems. This will include lessons and labs on basic electricity, electronics, basic physics, gears, torque, etc.
3. Programming
   ○ Use the program *VEXcode* to control the robot. *VEXcode* is a C++ language designed specifically for programming robots. This will coincide with the building of robots to complete specific tasks. VEXcode VR is a cloud-based robot simulator program which uses *Python*. It will be used to learn how to write algorithms to make the VR robot complete specific tasks.
4. Robots With Sensors
   ○ Students will build small autonomous robots which use sensors to perform specific tasks. It will include building robots for small in-class competitions.
5. Remote Control Robots
   ○ Students will build and program robots which will be controlled using a remote control.

Unit 1: Introduction to Robotics Engineering

Why Is This Unit Important?

Students will learn key STEM principles and robotics concepts. 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 does 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, and 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.

Formative

- Preparation & Participation
- Reading Discussions
- Assignments
- Design Projects
- Exams
- Do Now's
- Quizzes
- Guided Notes
- Classwork / Homework
- Exit Tickets

Summative

- Unit Tests
- Final Project

Suggested Learning Experiences and Instructional Activities:

- Lecture Introduction to industrial design
- Activity Product pitch
- Lecture The Design Process / Creativity in Design
- Lecture Brainstorming/Interview Techniques
- Activity Conducting Surveys
- Lecture Making Design Decisions Discussion
- Activity Morph chart and Evaluation Matrix
- Lecture Communication
- Activity- Group Presentations

Instructional Materials (including, but not limited to):

- Canvas
- Google Drive
- Sketch Notebook
- Scale or Straight Edge
- Colored Pencil Set
- Exacto-Knife
- Designkit.org
- The Art of Innovation (2001), Tom Kelley
- InGenius (2012), Tina Seelig
- Creative Confidence (2013), Tom Kelley & David Kelly

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 Automed 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:

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- VEX EDR STEM Labs
- VEXcode V5 Blocks - v1.0
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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
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List of Applicable Performance Expectations (PE) Covered in This Unit:

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

Accommodations

Special Education Students

Peer to peer assistance; reduce / revise assignments as per IEP; use manipulatives; calculators; extra time to complete task; provide individual & small group help; notes, and study guides; provide background knowledge; flexible grouping; peer grouping; visual demonstration; text magnification; color coding; repetition; pre-teaching; chunking; differentiating content; preferential seating; rephrasing of directions

English Language Learners

Use consistent, simplified language; provide bilingual partner; provide cooperative learning opportunities; use modeling; use visual aids & manipulatives; scaffolding; chunking the content; subtitles for videos

Students at Risk of Failure

Foster positive relationships; use mental models; provide help formulating specific questions; scaffolding; targeted support

Gifted Students

Provide additional enrichment activity involving demonstration of knowledge, or complementary assignments; independent practice; extension activities

Suggested Pacing

Unit (topic)	Anticipated time frame (days)
Design Process	5
Visualizations	5
Design Elements	20
Introduction to 3D Printing	20
Design Principles	20
Ergonomics & Human Centered Design	20

Sample Standards Integration

During this course, in addition to the New Jersey Student Learning Standards for Computer Science and Design Thinking, students will work on developing, to an age appropriate level, standards across content areas, including:

Career Readiness, Life Literacies, and Key Skills
9.4.8.CI.4: Explore the role of creativity and innovation in career pathways and industries.
Students will connect the concepts and skills in this course to potential future careers.

Social Studies
6.1.12.EconNE.16.b: Evaluate the economic, political, and social impact of new and emerging technologies on individuals and nations.
Students will discuss the positive and negative impacts of technological advancements.

Science
MS-PS1-6: Undertake a design project, engaging in the design cycle, to construct and/or implement a solution that meets specific design criteria and constraints.
Students will employ the design cycle to complete projects based on specific guidelines.

Mathematics
NJSLS-M.8.SP.A.2: Know that straight lines are widely used to model relationships between two quantitative variables. For scatter plots that suggest a linear association, informally fit a straight line, and informally assess the model fit (e.g. line of best fit) by judging the closeness of the data points to the line.
Students will interpret, analyze, and discuss data on diversity in technology careers and education.

English Language Arts
NJSLSA.W6: Use technology, including the Internet, to produce and publish writing and to interact and collaborate with others.
Students will engage in written discussion utilizing the district's digital learning environment.

Diversity, Equity & Inclusion

All students deserve equitable access (N.J.A.C. 6A:7) to a high-quality education that is inclusive and reflective of the rich diversity of our state. This curriculum will include learning activities that meet the legislative requirements of the 2019 History and Contributions of Individuals with Disabilities and LGBT (N.J.S.A. 18A:35-4.35-6) and Diversity and Inclusion statutes (N.J.S.A. 18A:35-4.36a) that may include:

- Students work in groups to develop a slide deck highlighting LGBTQ+ pioneers of computer science, such as Alan Turing, Edith Windsor, etc.
- Students will interpret, analyze, evaluate, and discuss data involving diversity in STEM fields (this may include the number of women enrolled in technology education programs, representation of people with disabilities in video games, etc.).