CURRICULUM FOR INTEGRATED STEM ROBOTICS

GRADES 9 - 12

This curriculum is part of the Educational Program of Studies of the Rahway Public Schools.

ACKNOWLEDGMENTS

Dr. Susan Dube, Program Supervisor Science/Technology Education

The Board acknowledges the following who contributed to the preparation of this curriculum.

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Subject/Course Title:
Technology/Integrated STEM Robotics
Grades 9-12

Date of Board Adoptions:
March 17, 2020

RAHWAY PUBLIC SCHOOLS CURRICULUM

Integrated STEM Robotics – Grades 9-12

PACING GUIDE

Unit	Title	Pacing
1	Robotics and Technology	2 weeks
2	Introduction to Hardware	2 weeks
3	Introduction to Software	4 weeks
4	Design & Mechanics	3 weeks
5	Sensors	3 weeks
6	Advanced Programming	3 weeks
7	Project Management	3 weeks

ACCOMMODATIONS

504 Accommodations:

- Provide scaffolded vocabulary and vocabulary lists.
- Provide extra visual and verbal cues and prompts.
- Provide adapted/alternate/excerpted versions of the text and/or modified supplementary materials.
- Provide links to audio files and utilize video clips.
- Provide graphic organizers and/or checklists.
- Provide modified rubrics.
- Provide a copy of teaching notes, especially any key terms, in advance.
- Allow additional time to complete assignments and/or assessments.
- Provide shorter writing assignments.
- Provide sentence starters.
- Utilize small group instruction.
- Utilize Think-Pair-Share structure.
- Check for understanding frequently.
- Have student restate information.
- Support auditory presentations with visuals.
- Weekly home-school communication tools (notebook, daily log, phone calls or email messages).
- Provide study sheets and teacher outlines prior to assessments.
- Quiet corner or room to calm down and relax when anxious.
- Reduction of distractions.
- Permit answers to be dictated.
- Hands-on activities.
- Use of manipulatives.
- Assign preferential seating.
- No penalty for spelling errors or sloppy handwriting.
- Follow a routine/schedule.
- Provide student with rest breaks.
- Use verbal and visual cues regarding directions and staying on task.
- Assist in maintaining agenda book.

IEP Accommodations:

- Provide scaffolded vocabulary and vocabulary lists.
- Differentiate reading levels of texts (e.g., Newsela).
- Provide adapted/alternate/excerpted versions of the text and/or modified supplementary materials.
- Provide extra visual and verbal cues and prompts.
- Provide links to audio files and utilize video clips.
- Provide graphic organizers and/or checklists.
- Provide modified rubrics.
- Provide a copy of teaching notes, especially any key terms, in advance.
- Provide students with additional information to supplement notes.
- Modify questioning techniques and provide a reduced number of questions or items on tests.
- Allow additional time to complete assignments and/or assessments.
- Provide shorter writing assignments.
- Provide sentence starters.
- Utilize small group instruction.
- Utilize Think-Pair-Share structure.
- Check for understanding frequently.
- Have student restate information.
- Support auditory presentations with visuals.
- Provide study sheets and teacher outlines prior to assessments.
- Use of manipulatives.
- Have students work with partners or in groups for reading, presentations, assignments, and analyses.
- Assign appropriate roles in collaborative work.
- Assign preferential seating.
- Follow a routine/schedule.

Gifted and Talented Accommodations:

- Differentiate reading levels of texts (e.g., Newsela).
- Offer students additional texts with higher lexile levels.
- Provide more challenging and/or more supplemental readings and/or activities to deepen understanding.
- Allow for independent reading, research, and projects.
- Accelerate or compact the curriculum.
- Offer higher-level thinking questions for deeper analysis.
- Offer more rigorous materials/tasks/prompts.
- Increase number and complexity of sources.
- Assign group research and presentations to teach the class.
- Assign/allow for leadership roles during collaborative work and in other learning activities.

ELL Accommodations:

- Provide extended time.
- Assign preferential seating.
- Assign peer buddy who the student can work with.
- Check for understanding frequently.
- Provide language feedback often (such as grammar errors, tenses, subject-verb agreements, etc…).
- Have student repeat directions.
- Make vocabulary words available during classwork and exams.
- Use study guides/checklists to organize information.
- Repeat directions.
- Increase one-on-one conferencing.
- Allow student to listen to an audio version of the text.
- Give directions in small, distinct steps.
- Allow copying from paper/book.
- Give student a copy of the class notes.
- Provide written and oral instructions.
- Differentiate reading levels of texts (e.g., Newsela).

	• Shorten assignments. • Read directions aloud to student. • Give oral clues or prompts. • Record or type assignments. • Adapt worksheets/packets. • Create alternate assignments. • Have student enter written assignments in criterion, where they can use the planning maps to help get them started and receive feedback after it is submitted. • Allow student to resubmit assignments. • Use small group instruction. • Simplify language. • Provide scaffolded vocabulary and vocabulary lists. • Demonstrate concepts possibly through the use of visuals. • Use manipulatives. • Emphasize critical information by highlighting it for the student. • Use graphic organizers. • Pre-teach or pre-view vocabulary. • Provide student with a list of prompts or sentence starters that they can use when completing a written assignment. • Provide audio versions of the textbooks. • Highlight textbooks/study guides. • Use supplementary materials. • Give assistance in note taking • Use adapted/modified textbooks. • Allow use of computer/word processor. • Allow student to answer orally, give extended time (time-and-a-half). • Allow tests to be given in a separate location (with the ESL teacher). • Allow additional time to complete assignments and/or assessments. • Read question to student to clarify. • Provide a definition or synonym for words on a test that do not impact the validity of the exam. • Modify the format of assessments. • Shorten test length or require only selected test items. • Create alternative assessments. • On an exam other than a spelling test, don't take points off for spelling errors.

RAHWAY PUBLIC SCHOOLS CURRICULUM

UNIT OVERVIEW

Content Area: Integrated STEM Robotics

Unit Title: Unit 1-Robotics and Technology

Target Course/Grade Level: Elective Course, Grades 9-12

Unit Summary: In this unit students will explore the definitions of robotics and technology. Students will learn about fictional and modern day examples of robots. Students will also learn about the engineering design process and how technology is developed to combat the problems of the modern world.

Approximate Length of Unit: 2 Weeks

LEARNING TARGETS

NJ Student Learning Standards:

- 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.A.2 Analyze a current technology and the resources used, to identify the trade-offs in terms of availability, cost, desirability and waste.
- 8.2.12.A.3 Research and present information on an existing technological product that has been repurposed for a different function.
- 8.2.12.B.3 Analyze ethical and unethical practices around intellectual property rights as influenced by human wants and/or needs.

21st Century Life and Career Skills:

- 9.3.12.AC-DES.6 Apply the techniques and skills of modern drafting, design, engineering and construction to projects.
- 9.3.MN-QA.3 Coordinate work teams to create a product that meets quality assurance standards.
- 9.3.ST.1 Apply engineering skills in a project that requires project management, process control and quality assurance.
- 9.3.ST-ET.4 Apply the elements of the design process.

21st Century Learning Standards:

Career Ready Practices:

- CRP1. Act as a responsible and contributing citizen and employee.
- CRP2. Apply appropriate academic and technical skills.
- CRP4. Communicate clearly and effectively and with reason.
- CRP5. Consider the environmental, social and economic impacts of decisions.
- CRP6. Demonstrate creativity and innovation.
- CRP7. Employ valid and reliable research strategies.
- CRP8. Utilize critical thinking to make sense of problems and persevere in solving them.
- CRP9. Model integrity, ethical leadership and effective management.
- CRP11. Use technology to enhance productivity.

- CRP12. Work productively in teams while using cultural global competence.

Interdisciplinary Connections and Standards:

- HS-ETS1-2. Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.
- HS-ETS1-4. Use a computer simulation to model the impact of proposed solutions to a complex real-world problem with numerous criteria and constraints on interactions within and between systems relevant to the problem.
- G-GMG.A1. Use geometric shapes, their measures, and their properties to describe objects (e.g., modeling a tree trunk or a human torso as a cylinder).

Mathematical Practices

1. Make sense of problems and persevere in solving them.
2. Reason abstractly and quantitatively.
3. Construct viable arguments and critique the reasoning of others.
4. Model with mathematics.
5. Use appropriate tools strategically.

NJ SLS Companion Standards: Reading and Writing Standards for History, Social Studies, Science, and Technical Subjects:

- RST.9-10.3. Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks, attending to special cases or exceptions defined in the text.
- RST.9-10.5. Analyze the relationships among concepts in a text, including relationships among key terms (e.g., force, friction, reaction force, energy).
- RST.9-10.7. Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words.

Unit Understandings:

Students will understand that…

- Technology is designed to alleviate the problems of the modern world
- Technology has developed over time through scientific knowledge
- A product can always be redesigned and improved
- Robots, real and fictional, are created to assist mankind
- Robots are the combination of hardware and software

Unit Essential Questions:

- What makes an item technology?
- How has technology changed over time?
- What makes a machine a robot?
- How do robots aid mankind?
- How are robots portrayed in fiction?

Knowledge and Skills:

Students will know…..

- • The definition of the following terms:
    - Engineering

    - Robotics
    - Androids
    - Cyborgs
    - Processors
    - Electronics and circuits
    - Hardware
    - software
- The engineering design process
- The history of robotic technology
- The development of technology over time.
- Examples of fictional and real modern robots

Students will be able to …

- Compare robots based on their design and function
- Compare the different categories of technology
- Identify and utilize the steps of the Engineering Design Process
- Solve basic design challenges through an engineer's mentality

EVIDENCE OF LEARNING

Assessment:

What evidence will be collected and deemed acceptable to show that students truly "understand"?

- **End of Unit Assessment:** Group based design activities
    - Students will be given several design challenges in which they will cooperate as a group to solve a simple problem. Students will be assessed on their ability to plan, construct, and redesign their solutions.
- Independent technology presentation
    - Students will each pick a piece of modern technology. Students will then create a short presentation that highlights the purpose, history, and development of their chosen technology. Students will also have to identify the technology's role in the modern world. Students will be assessed based on the research they include, the design of their presentation, and the overall content of the presentation.
- General class participation
- Completion of worksheets and note sheets that accompany the lessons/lectures

Learning Activities:

What differentiated learning experiences and instruction will enable all students to achieve the desired results?

- Class lectures
- Station activities
- Design challenge competitions
- Supportive worksheets
- Independent research projects

RESOURCES

Teacher Resources:

- Presentations developed for class lectures
- Teacher designed example robots

Equipment Needed:

- Classroom computers
- Screencast software
- Lego Mindstorm kits

UNIT OVERVIEW

Content Area: Integrated STEM Robotics

Unit Title: Unit 2-Introduction to Hardware

Target Course/Grade Level: Elective Course, Grades 9-12

Unit Summary: In this unit students will learn about how hardware and the physical structure of a robot affect its functionality. Students will work with the Lego Mindstorm kits and will be able to identify the function of the major piece categories. Students will be able to build basic robots using the provided Lego materials.

Approximate Length of Unit: 2 Weeks

LEARNING TARGETS

NJ Student Learning Standards

- 8.2.12.C.1 Explain how open source technologies follow the design process.
- 8.2.12.C.2 Analyze a product and how it has changed or might change over time to meet human needs and wants
- 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.

21st Century Life and Career Skills:

- 9.3.MN-QA.3 Coordinate work teams to create a product that meets quality assurance standards.
- 9.3.ST-ET.4 Apply the elements of the design process.
- 9.3.ST-ET.5 Apply the knowledge learned in STEM to solve problems.

21st Century Learning Standards:
Career Ready Practices:

- CRP1. Act as a responsible and contributing citizen and employee.
- CRP2. Apply appropriate academic and technical skills.
- CRP4. Communicate clearly and effectively and with reason.
- CRP5. Consider the environmental, social and economic impacts of decisions.
- CRP6. Demonstrate creativity and innovation.
- CRP7. Employ valid and reliable research strategies.
- CRP8. Utilize critical thinking to make sense of problems and persevere in solving them.
- CRP9. Model integrity, ethical leadership and effective management.
- CRP11. Use technology to enhance productivity.
- CRP12. Work productively in teams while using cultural global competence.

NJ SLS Companion Standards: Reading and Writing Standards for History, Social Studies, Science, and Technical Subjects:

- RST.9-10.3. Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks, attending to special cases or exceptions defined in the text.
- RST.9-10.5. Analyze the relationships among concepts in a text, including relationships among key terms (e.g., force, friction, reaction force, energy).
- RST.9-10.7. Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words.

Interdisciplinary Connections and Standards:

- HS-ETS1-2. Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.
- HS-ETS1-4. Use a computer simulation to model the impact of proposed solutions to a complex real-world problem with numerous criteria and constraints on interactions within and between systems relevant to the problem.
- G-GMG.A1. Use geometric shapes, their measures, and their properties to describe objects (e.g., modeling a tree trunk or a human torso as a cylinder).
- RST.9-10.3. Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks, attending to special cases or exceptions defined in the text.
- RST.9-10.5. Analyze the relationships among concepts in a text, including relationships among key terms (e.g., force, friction, reaction force, energy).
- RST.9-10.7. Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words.

Mathematical Practices

1. Make sense of problems and persevere in solving them.
2. Reason abstractly and quantitatively.
3. Construct viable arguments and critique the reasoning of others.
4. Model with mathematics.
5. Use appropriate tools strategically.

Unit Understandings:

Students will understand that…

- Robotic form controls functionality
- Robots need both hardware and software in order to function
- Robots require electricity in order to function
- Motion is created through electronic components like motors
- Beams and connectors can be used to give form to classroom robots
- Axles are pieces used to create rotational motion

Unit Essential Questions:

- Why is it important to maintain a clean and organized robotics lab?
- How does a robot’s function influence its form?
- What does tolerance mean in terms of building? How does a part’s tolerance affect its function?
- What makes a mechanical system stable?
- How can a robot’s structure be made durable?
- How does material choice affect the function of a designed product?
- How can robots be designed to function after repeated usage?

Knowledge and Skills:
Students will know…..

- The location of the part storage bins and classwork storage bins within the classroom
- The major categories of Lego parts that will be used throughout the class
- The function of beams to create structure
- The function of axles and other rotational components
- The process for connecting beams securely
- The effect of form on functionality

Students will be able to …

- Find specific parts in the classroom storage system
- Compare the primary use of different parts
- Determine the function of a robot based on construction
- Build basic robots from provided instructions
- Properly store materials and maintain the classroom build areas

EVIDENCE OF LEARNING

Assessment:

What evidence will be collected and deemed acceptable to show that students truly "understand"?

- **End of Unit Assessment:** Instruction Build Projects
  - Students will be given several examples of robots and mechanical systems that they will need to create. Students will work in small groups to build each example. Students will be assessed on the completion of each build, participation for the builds, and build analysis questions.
- **End of Unit Assessment:** Demonstration Robot Build
  - Students will work in small groups to build a base robot designed by the teacher. The students will be provided an instruction manual for the robot. This robot will be used as an example for the next unit on programming. Students will be assessed based on their ability to complete the build and on their responses to a set of analysis questions based on the build.
- General class participation
- Completion of worksheets and note sheets that accompany the lessons/lectures

Learning Activities:
What differentiated learning experiences and instruction will enable all students to achieve the desired results?

- Class lectures
- Station activities
- Small group build activities
- Teacher designed robot demonstrations

RESOURCES

Teacher Resources:

- Presentations developed for class lectures
- Teacher designed example robots

- Teacher developed example instruction manuals
- Lego part measurement sheets

Equipment Needed:

- Classroom computers
- Screencast software
- Lego Mindstorms kits
- Classroom Lego storage shelves

RAHWAY PUBLIC SCHOOLS CURRICULUM

UNIT OVERVIEW

Content Area: Integrated STEM Robotics

Unit Title: Unit 3-Introduction to Software

Target Course/Grade Level: Elective Course, Grades 9-12

Unit Summary: In this unit students will learn about software and how code programs control computer and robotic systems. Students will learn about the general layout of Lego EV3, the program they will use to control robots throughout the course. Students will learn about basic code formats. Students will learn how to program actions and basic reactions using the Lego software.

Approximate Length of Unit: 4 Weeks

LEARNING TARGETS

NJ Student Learning Standards

- 8.2.12.C.1 Explain how open source technologies follow the design process.
- 8.2.12.C.2 Analyze a product and how it has changed or might change over time to meet human needs and wants
- 8.2.12.C.4 Explain and identify interdependent systems and their functions.
- 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).

21st Century Life and Career Skills:

- 9.3.ST.6 Demonstrate technical skills needed in a chosen STEM field.
- 9.3.ST-ET.5 Apply the knowledge learned in STEM to solve problems.

21st Century Learning Standards:
Career Ready Practices:

- CRP1. Act as a responsible and contributing citizen and employee.
- CRP2. Apply appropriate academic and technical skills.
- CRP4. Communicate clearly and effectively and with reason.
- CRP5. Consider the environmental, social and economic impacts of decisions.
- CRP6. Demonstrate creativity and innovation.
- CRP7. Employ valid and reliable research strategies.
- CRP8. Utilize critical thinking to make sense of problems and persevere in solving them.
- CRP9. Model integrity, ethical leadership and effective management.
- CRP11. Use technology to enhance productivity.
- CRP12. Work productively in teams while using cultural global competence.

NJ SLS Companion Standards: Reading and Writing Standards for History, Social Studies, Science, and Technical Subjects:

- RST.9-10.3. Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks, attending to special cases or exceptions defined in the text.
- RST.9-10.5. Analyze the relationships among concepts in a text, including relationships among key terms (e.g., force, friction, reaction force, energy).
- RST.9-10.7. Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words.

Interdisciplinary Connections and Standards:

- HS-ETS1-2. Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.
- HS-ETS1-4. Use a computer simulation to model the impact of proposed solutions to a complex real-world problem with numerous criteria and constraints on interactions within and between systems relevant to the problem.
- RST.9-10.3. Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks, attending to special cases or exceptions defined in the text.
- RST.9-10.5. Analyze the relationships among concepts in a text, including relationships among key terms (e.g., force, friction, reaction force, energy).
- RST.9-10.7. Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words.

Mathematical Practices

1. Make sense of problems and persevere in solving them.
2. Reason abstractly and quantitatively.
3. Construct viable arguments and critique the reasoning of others.
4. Model with mathematics.
5. Use appropriate tools strategically.

Unit Understandings:

Students will understand that…

- Robots utilize code to control both actions and reactions
- Autonomous robots rely heavily on programming to function without user operation
- Robotic programs use inputs or sensor data to influence outputs (reactions)
- Code programs run in a linear fashion, but can perform different outcomes through logical control structures
- Programs can function through repeating sections and if...else control structures

Unit Essential Questions:

- How does a program control physical functions?
- How can different code elements be used to create the same result?
- How are loops used for programming? Why are loops essential for autonomous programming?
- How do if...else (switch) programs function? How can they be used to create true robotic reactions?
- What makes a program efficient?
- What does the move steering programming block do? How can it control robotic movement?
- What is the difference between a wait and a switch block?

- How do parameters influence wait and switch blocks?

Knowledge and Skills:
Students will know…..

- The general layout of Lego EV3
- The definitions of inputs and outputs in relation to programming
- The categories of programming blocks available in EV3
- The purpose and parameters of the following blocks:
    - Wait
    - Switch
    - Move steering
    - Large motor
    - Medium motor
    - Loop
    - Comment
- How programs control physical components
- How programs utilize logic and data to function

Students will be able to …

- Create and properly save Lego EV3 programs
- Control movement through usage of the move steering block
- Utilize wait blocks to make robots either repeat actions or pause based on environmental data
- Create simple codes that utilize wait, switch, loop, and move steering blocks

EVIDENCE OF LEARNING

Assessment:
What evidence will be collected and deemed acceptable to show that students truly "understand"?

- **End of Unit Assessment:** Code Prompt Programs
    - Students will be given several code prompts in which they need to analyze the prompt, determine the necessary code blocks, and create a functional program. Students will be assessed based on the functionality of their programs.
- **Programming Unit Assessment**
    - Students will take a quiz on the basic programming elements of Lego EV3. Students will need to identify code blocks and their functions, analyze code blocks to determine their functions, and determine parameter values to meet given prompts. Students will also need to complete one code prompt that will be submitted with the quiz.
- General class participation
- Completion of worksheets and note sheets that accompany the lessons/lectures

Learning Activities:

What differentiated learning experiences and instruction will enable all students to achieve the desired results?

- Class lectures
- Teacher demonstrated programming walkthroughs

- Teacher designed robot demonstrations
- Classwork programming prompt activities

RESOURCES

Teacher Resources:

- Presentations developed for class lectures
- Teacher designed example robots and their code programs
- Teacher developed code block guides for each of the covered blocks
- Teacher designed programming prompts

Equipment Needed:

- Classroom computers
- Screencast software
- Lego Mindstorms kits

RAHWAY PUBLIC SCHOOLS CURRICULUM

UNIT OVERVIEW

Content Area: Integrated STEM Robotics

Unit Title: Unit 4-Design and Mechanics

Target Course/Grade Level: Elective Course, Grades 9-12

Unit Summary: In this unit students will learn about mechanical systems and their effect on robotic function. Students will observe and build several mechanical systems such as: lifts, arms, steering systems, and claws. The unit will culminate with a design challenge in which students will need to design a robot for a class competition.

Approximate Length of Unit: 3 Weeks

LEARNING TARGETS

NJ Student Learning Standards

- 8.2.12.C.6 Research an existing product, reverse engineer and redesign it to improve form and function.
- 8.2.12.C.7 Use a design process to devise a technological product or system that addresses a global problem, provide research, identify trade-offs and constraints, and document the process through drawings that include data and materials.
- 8.2.12.D.1 Design and create a prototype to solve a real world problem using a design process, identify constraints addressed during the creation of the prototype, identify trade-offs made, and present the solution for peer review.
- 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.

21st Century Life and Career Skills:

- 9.3.MN-QA.3 Coordinate work teams to create a product that meets quality assurance standards.
- 9.3.ST.1 Apply engineering skills in a project that requires project management, process control and quality assurance.
- 9.3.ST-ET.4 Apply the elements of the design process.
- 9.3.ST.6 Demonstrate technical skills needed in a chosen STEM field.
- 9.3.ST-ET.5 Apply the knowledge learned in STEM to solve problems.

21st Century Learning Standards:

Career Ready Practices:

- CRP1. Act as a responsible and contributing citizen and employee.
- CRP2. Apply appropriate academic and technical skills.
- CRP4. Communicate clearly and effectively and with reason.
- CRP5. Consider the environmental, social and economic impacts of decisions.
- CRP6. Demonstrate creativity and innovation.
- CRP7. Employ valid and reliable research strategies.
- CRP8. Utilize critical thinking to make sense of problems and persevere in solving them.
- CRP9. Model integrity, ethical leadership and effective management.

- CRP11. Use technology to enhance productivity.
- CRP12. Work productively in teams while using cultural global competence.

NJ SLS Companion Standards: Reading and Writing Standards for History, Social Studies, Science, and Technical Subjects:

● RST.9-10.3. Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks, attending to special cases or exceptions defined in the text.
● RST.9-10.5. Analyze the relationships among concepts in a text, including relationships among key terms (e.g., force, friction, reaction force, energy).
● RST.9-10.7. Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words.

Interdisciplinary Connections and Standards:

- RST.9-10.3. Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks, attending to special cases or exceptions defined in the text.
- RST.9-10.5. Analyze the relationships among concepts in a text, including relationships among key terms (e.g., force, friction, reaction force, energy).
- RST.9-10.7. Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words.
- HS-ETS1-2. Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.
- HS-ETS1-3. Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts.
- HS-ETS1-4. Use a computer simulation to model the impact of proposed solutions to a complex real-world problem with numerous criteria and constraints on interactions within and between systems relevant to the problem.

Mathematical Practices

1. Make sense of problems and persevere in solving them.
2. Reason abstractly and quantitatively.
3. Construct viable arguments and critique the reasoning of others.
4. Model with mathematics.
5. Use appropriate tools strategically.

Unit Understandings:

Students will understand that…

- Mechanical systems allow components like motors to be used for a variety of functions
- Mechanical components can be combined to create advanced multipurpose robots
- Motors naturally create rotational motion
- Through mechanical systems motion can be transferred between linear motion and rotational motion
- Limit switches can be used to better control mechanical systems
- Different size gears can produce increased torque or speed when combined

Unit Essential Questions:

- What makes something a mechanical system?
- What are the different types of mechanical motion?
- How do different mechanical system change the functionality of a robot?

- How can limit switches make it easier to control mechanical components?
- How can mechanical systems be combined to increase robot functionality?

Knowledge and Skills:
Students will know…..

- The definition of mechanical systems
- The difference between linear and rotational motion
- The process for creating simple lifts, manipulators, and arms through use of Legos
- The functions of several teacher provided mechanical systems
- The purpose of gear ratios
- The relationship between torque and speed

Students will be able to …

- Build several example mechanical systems from instructions
- Calculate gear ratio and identify the increase in power or speed
- Compare the design and function of mechanical systems
- Create mechanical systems to convert rotational motion to linear motion
- Design a robot to solve a given competition style problem

EVIDENCE OF LEARNING

Assessment:
What evidence will be collected and deemed acceptable to show that students truly "understand"?

- Mechanical system build activities
    - Students will work in small groups to build mechanical systems based off of provided instructions. Students will be assessed based on the completion of their builds and the analysis responses that accompany them.
- **End of Unit Assessment:** Competition Style Design Project
    - Students will work in small groups to design a robot for a competition style project. Students will need to abide by several given constraints and limitations for the design of their robots. Students will be assessed based on the design of their robot, the features included on their robot, the functionality and performance of their robot, participation, and a redesign analysis after completion of the project.
- General class participation
- Completion of worksheets and note sheets that accompany the lessons/lectures

Learning Activities:

What differentiated learning experiences and instruction will enable all students to achieve the desired results?

- Class lectures
- Small group build activities
- Station activities
- Teacher designed robot demonstrations
- Small group competition style build project

RESOURCES

Teacher Resources:

- Presentations developed for class lectures
- Teacher designed example mechanical systems and their code programs
- Instruction manuals for sample mechanical systems

Equipment Needed:

- Classroom computers
- Screencast software
- Lego Mindstroms kits

RAHWAY PUBLIC SCHOOLS CURRICULUM

UNIT OVERVIEW

Content Area: Integrated STEM Robotics

Unit Title: Unit 5-Sensors

Target Course/Grade Level: Elective Course, Grades 9-12

Unit Summary: In this unit students will learn about sensors and their function in robotic design. Students will learn about different types of sensors and the data they measure. Students will complete various design and programming activities that utilize sensors in order to create autonomous robot functions.

Approximate Length of Unit: 3 Weeks

LEARNING TARGETS

NJ Student Learning Standards

- 8.2.12.A.2 Analyze a current technology and the resources used, to identify the trade-offs in terms of availability, cost, desirability and waste.
- 8.2.12.A.3 Research and present information on an existing technological product that has been repurposed for a different function.
- 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.

21st Century Life and Career Skills:

- 9.3.ST.6 Demonstrate technical skills needed in a chosen STEM field.
- 9.3.ST-ET.5 Apply the knowledge learned in STEM to solve problems.
- 9.3.ST.1 Apply engineering skills in a project that requires project management, process control and quality assurance.
- 9.3.ST-ET.4 Apply the elements of the design process.

21st Century Learning Standards:
Career Ready Practices:

- CRP1. Act as a responsible and contributing citizen and employee.
- CRP2. Apply appropriate academic and technical skills.
- CRP4. Communicate clearly and effectively and with reason.
- CRP5. Consider the environmental, social and economic impacts of decisions.
- CRP6. Demonstrate creativity and innovation.
- CRP7. Employ valid and reliable research strategies.
- CRP8. Utilize critical thinking to make sense of problems and persevere in solving them.
- CRP9. Model integrity, ethical leadership and effective management.
- CRP11. Use technology to enhance productivity.

- CRP12. Work productively in teams while using cultural global competence.

NJ SLS Companion Standards: Reading and Writing Standards for History, Social Studies, Science, and Technical Subjects:

- RST.9-10.3. Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks, attending to special cases or exceptions defined in the text.
- RST.9-10.5. Analyze the relationships among concepts in a text, including relationships among key terms (e.g., force, friction, reaction force, energy).
- RST.9-10.7. Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words.

Interdisciplinary Connections and Standards:

- HS-ETS1-4. Use a computer simulation to model the impact of proposed solutions to a complex real-world problem with numerous criteria and constraints on interactions within and between systems relevant to the problem.
- RST.9-10.3. Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks, attending to special cases or exceptions defined in the text.
- RST.9-10.5. Analyze the relationships among concepts in a text, including relationships among key terms (e.g., force, friction, reaction force, energy).
- RST.9-10.7. Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words.
- G-CO.A4 Develop definitions of rotations, reflections, and translations in terms of angles, circles, perpendicular lines, parallel lines, and line segments.

Mathematical Practices

1. Make sense of problems and persevere in solving them.
2. Reason abstractly and quantitatively.
3. Construct viable arguments and critique the reasoning of others.
4. Model with mathematics.
5. Use appropriate tools strategically.

Unit Understandings:

Students will understand that…

- Sensors are tools used to measure data from the environment
- Sensors can be used to help robots navigate and react to their environment
- Each sensor measures one specific aspect of a robot's environment
- Sensors can be used to control reactions through programming
- Sensors are input devices
- Inputs can be used to determine the output reactions of a robot

Unit Essential Questions:

- What is the purpose of a sensor?
- How do sensor choices affect robotic design?
- How can external measurements influence a robot's actions?
- How can sensors be used to allow a robot to navigate autonomously?
- How does the quality of a sensor affect its functionality?

Knowledge and Skills:

Students will know…..

- The definition of sensors and their purpose in terms of robotics
- The available sensors in the classroom and the values they measure
- The concept of a data range in terms of programming
- How sensors can imitate natural senses (biomimicry)
- The differences between the available sensors in the classroom
- How sensors are used in every day technology like cell phones

Students will be able to …

- Utilize touch, gyro, ultrasonic, and sound sensors
- Compare the available sensors and determine which sensor is appropriate based on the function of a robot
- Program robots to navigate autonomously with individual and combinations of sensors
- Identify the sensors used in technology like the robotic vacuum cleaner
- Use sensor values in both switch and wait code blocks

EVIDENCE OF LEARNING

Assessment:

What evidence will be collected and deemed acceptable to show that students truly "understand"?

- Code Prompt Programs
    - Students will be given several code prompts in which they need to analyze the prompt, determine the necessary code blocks, and create a functional program. Students will be assessed based on the functionality of their programs.

- **End of Unit Assessment:** Maze Programming Challenge

    - Students will be tasked with solving multiple mazes using a given set of sensors. Students will work either alone or with a partner for each maze. Students will be assessed on the functionality and build quality of their robot.

- General class participation
- Completion of worksheets and note sheets that accompany the lessons/lectures

Learning Activities:

What differentiated learning experiences and instruction will enable all students to achieve the desired results?

- Class lectures
- Programming prompt activities
- Small group build activities
- Station activities
- Teacher designed robot demonstrations
- Designated project work time

RESOURCES

Teacher Resources:

- Presentations developed for class lectures
- Programming prompts
- Teacher developed robots

- Instruction manuals for sample mechanical systems

Equipment Needed:

- Classroom computers
- Screencast software
- Lego Mindstorms kits

RAHWAY PUBLIC SCHOOLS CURRICULUM

UNIT OVERVIEW

Content Area: Integrated STEM Robotics

Unit Title: Unit 6-Advanced Programming

Target Course/Grade Level: Elective Course, Grades 9-12

Unit Summary: In this unit students will learn about advanced coding methods. Students will learn how to use variables and complex control structures. Students will be able to program multiple output reactions based on complex variables.

Approximate Length of Unit: 3 Weeks

LEARNING TARGETS

NJ Student Learning Standards

- 8.2.12.A.2 Analyze a current technology and the resources used, to identify the trade-offs in terms of availability, cost, desirability and waste.
- 8.2.12.A.3 Research and present information on an existing technological product that has been repurposed for a different function.
- 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.

21st Century Life and Career Skills:

- 9.3.ST.6 Demonstrate technical skills needed in a chosen STEM field.
- 9.3.ST-ET.5 Apply the knowledge learned in STEM to solve problems.
- 9.3.ST.1 Apply engineering skills in a project that requires project management, process control and quality assurance.
- 9.3.ST-ET.4 Apply the elements of the design process.

21st Century Learning Standards:

Career Ready Practices:

- CRP1. Act as a responsible and contributing citizen and employee.
- CRP2. Apply appropriate academic and technical skills.
- CRP4. Communicate clearly and effectively and with reason.

- CRP5. Consider the environmental, social and economic impacts of decisions.
- CRP6. Demonstrate creativity and innovation.
- CRP7. Employ valid and reliable research strategies.
- CRP8. Utilize critical thinking to make sense of problems and persevere in solving them.
- CRP9. Model integrity, ethical leadership and effective management.
- CRP11. Use technology to enhance productivity.
- CRP12. Work productively in teams while using cultural global competence.

NJ SLS Companion Standards: Reading and Writing Standards for History, Social Studies, Science, and Technical Subjects:

● RST.9-10.3. Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks, attending to special cases or exceptions defined in the text.

● RST.9-10.5. Analyze the relationships among concepts in a text, including relationships among key terms (e.g., force, friction, reaction force, energy).

● RST.9-10.7. Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words.

Interdisciplinary Connections and Standards:

- HS-ETS1-4. Use a computer simulation to model the impact of proposed solutions to a complex real-world problem with numerous criteria and constraints on interactions within and between systems relevant to the problem.
- RST.9-10.3. Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks, attending to special cases or exceptions defined in the text.
- RST.9-10.5. Analyze the relationships among concepts in a text, including relationships among key terms (e.g., force, friction, reaction force, energy).
- RST.9-10.7. Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words.
- G-CO.A4 Develop definitions of rotations, reflections, and translations in terms of angles, circles, perpendicular lines, parallel lines, and line segments.

Mathematical Practices

1. Make sense of problems and persevere in solving them.
2. Reason abstractly and quantitatively.
3. Construct viable arguments and critique the reasoning of others.
4. Model with mathematics.
5. Use appropriate tools strategically.

Unit Understandings:

Students will understand that…

- Variables in programming work similarly to variables in math
- Variables can be manipulated in order to change a robot's actions
- Logic and mathematics are key to program complex actions

Unit Essential Questions:

- How do variables work in EV3?
- How can a variable be used to control a robot?
- What makes a code fail?

Knowledge and Skills:

Students will know…..

- The use and function of the following code blocks in Lego EV3:
  - Switch (variable)
  - Variable
  - Mathematics
- The interactions between variables, functions, and output reactions
- The definition of a variable as a carrier for a data value

Students will be able to …

- Utilize touch, gyro, ultrasonic, and sound sensors
- Compare the available sensors and determine which sensor is appropriate based on the function of a robot
- Program robots to navigate autonomously with individual and combinations of sensors
- Identify the sensors used in technology like the robotic vacuum cleaner
- Use sensor values in both switch and wait code blocks

EVIDENCE OF LEARNING

Assessment:

What evidence will be collected and deemed acceptable to show that students truly "understand"?

- Code Prompt Programs
  - Students will be given several code prompts in which they need to analyze the prompt, determine the necessary code blocks, and create a functional program. Students will be assessed based on the functionality of their programs.

- **End of Unit Assessment:** Maze Programming Challenge

  - Students will be tasked with solving multiple mazes using a given set of sensors. Students will work either alone or with a partner for each maze. Students will be assessed on the functionality and build quality of their robot.

- General class participation
- Completion of worksheets and note sheets that accompany the lessons/lectures

Learning Activities:

What differentiated learning experiences and instruction will enable all students to achieve the desired results?

- Class lectures
- Programming prompt activities
- Small group build activities
- Station activities
- Teacher designed robot demonstrations

RESOURCES

Teacher Resources:

- Presentations developed for class lectures
- Programming prompts
- Teacher developed robots
- Instruction manuals for sample mechanical systems

Equipment Needed:

- Classroom computers
- Screencast software
- Lego Mindstorms kits

RAHWAY PUBLIC SCHOOLS CURRICULUM

UNIT OVERVIEW

Content Area: Integrated STEM Robotics

Unit Title: Unit 7- Project Management

Target Course/Grade Level: Elective Course, Grades 9-12

Unit Summary: In this unit students will learn to work together as a team to design a solution to a given problem using the engineering design process and their knowledge of robotics.

Approximate Length of Unit: 3 Weeks

LEARNING TARGETS

NJ Student Learning Standards

- 8.2.12.C.6 Research an existing product, reverse engineer and redesign it to improve form and function.
- 8.2.12.C.7 Use a design process to devise a technological product or system that addresses a global problem, provide research, identify trade-offs and constraints, and document the process through drawings that include data and materials.
- 8.2.12.D.1 Design and create a prototype to solve a real world problem using a design process, identify constraints addressed during the creation of the prototype, identify trade-offs made, and present the solution for peer review.
- 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.

21st Century Life and Career Skills:

- 9.3.MN-QA.3 Coordinate work teams to create a product that meets quality assurance standards.
- 9.3.ST.1 Apply engineering skills in a project that requires project management, process control and quality assurance.
- 9.3.ST-ET.4 Apply the elements of the design process.
- 9.3.ST.6 Demonstrate technical skills needed in a chosen STEM field.
- 9.3.ST-ET.5 Apply the knowledge learned in STEM to solve problems.

21st Century Learning Standards:
Career Ready Practices:

- CRP1. Act as a responsible and contributing citizen and employee.
- CRP2. Apply appropriate academic and technical skills.
- CRP4. Communicate clearly and effectively and with reason.
- CRP5. Consider the environmental, social and economic impacts of decisions.
- CRP6. Demonstrate creativity and innovation.
- CRP7. Employ valid and reliable research strategies.
- CRP8. Utilize critical thinking to make sense of problems and persevere in solving them.
- CRP9. Model integrity, ethical leadership and effective management.
- CRP11. Use technology to enhance productivity.

- CRP12. Work productively in teams while using cultural global competence.

Interdisciplinary Connections and Standards:

- RST.9-10.3. Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks, attending to special cases or exceptions defined in the text.
- RST.9-10.5. Analyze the relationships among concepts in a text, including relationships among key terms (e.g., force, friction, reaction force, energy).
- RST.9-10.7. Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words.
- HS-ETS1-2. Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.
- HS-ETS1-3. Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts.
- HS-ETS1-4. Use a computer simulation to model the impact of proposed solutions to a complex real-world problem with numerous criteria and constraints on interactions within and between systems relevant to the problem.

Mathematical Practices

1. Make sense of problems and persevere in solving them.
2. Reason abstractly and quantitatively.
3. Construct viable arguments and critique the reasoning of others.
4. Model with mathematics.
5. Use appropriate tools strategically**.**

Unit Understandings:

Students will understand that…

- The engineering design process is used to design solutions to problems engineers face
- Projects, like programming tasks, should be broken down into smaller pieces in order to work more efficiently
- A detailed plan is essential for constructing complex robots and projects
- Problems in engineering often have multiple solutions
- Tradeoffs are features of design that sacrifice certain elements for functionality

Unit Essential Questions:

- How can a complex problem be broken down into pieces?
- How can robotic technology be used to solve the problems faced by modern day society?
- What makes a robot functional?
- When is a piece of technology’s failure beneficial?
- How can functional solutions be redesigned and improved?

Knowledge and Skills:

Students will know…..

- The steps of the engineering design process and their functions
- The structure of a Gantt chart for time management
- The relationship between designed code programs and physical robotic components
- The process for designing, testing, evaluating, and redesigning a robot

Students will be able to …

- Build a robot as a group to solve a real world problem
- Plan an efficient schedule for a design build
- Break down a problem into smaller more manageable pieces
- Work together with a group of peers
- Present a design and its test results to a group of peers
- Test, evaluate, and redesign a robot to better suit its purpose

EVIDENCE OF LEARNING

Assessment:

What evidence will be collected and deemed acceptable to show that students truly "understand"?

- General class participation
- **End of Unit Assessment:** Final Design Project
    - Students will be broken up into groups of either 3 or 4 and will be tasked with creating a robot that solves a given "real world" problem. Students will have several weeks to plan, build, and test their projects. Students will be evaluated on their engineering notebooks, their constructed robot, and their overall participation for the project.

Learning Activities:

What differentiated learning experiences and instruction will enable all students to achieve the desired results?

- Teacher designed robot demonstrations
- Teacher to group project conferences
- Designated project work class periods

RESOURCES

Teacher Resources:

- Teacher developed project design prompt
- Gantt chart template
- Example projects created by the teacher

Equipment Needed:

- Classroom computers
- Screencast software
- Lego Mindstorms kits