# CURRICULUM

# FOR

# ADVANCED ROBOTICS

# GRADES 10 - 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.

**Noah Walsh**

**Tiffany Beer, Director of Curriculum and Instruction**

Subject/Course Title:
**Technology/Advanced Robotics**
**Grades 10-12**

Date of Board Adoptions:
**September 17, 2019**

**RAHWAY PUBLIC SCHOOLS CURRICULUM**

**Advanced Robotics – Grades 10-12**

***PACING GUIDE***

| Unit | Title | Pacing |
|---|---|---|
| 1 | Basic Lego Robotics Code & Design | 6 weeks |
| 2 | Structural Stability | 5 weeks |
| 3 | Software & Programming | 6 weeks |
| 4 | Mechanical Systems | 5 weeks |
| 5 | Sensors & Automation | 4 weeks |
| 6 | Robot Design & Functionality | 5 weeks |
| 7 | Problem Solving Using Robotics | 5 weeks |
| 8 | User Robot Control | 4 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.<br>• Read directions aloud to student.<br>• Give oral clues or prompts.<br>• Record or type assignments.<br>• Adapt worksheets/packets.<br>• Create alternate assignments.<br>• 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.<br>• Allow student to resubmit assignments.<br>• Use small group instruction.<br>• Simplify language.<br>• Provide scaffolded vocabulary and vocabulary lists.<br>• Demonstrate concepts possibly through the use of visuals.<br>• Use manipulatives.<br>• Emphasize critical information by highlighting it for the student.<br>• Use graphic organizers.<br>• Pre-teach or pre-view vocabulary.<br>• Provide student with a list of prompts or sentence starters that they can use when completing a written assignment.<br>• Provide audio versions of the textbooks.<br>• Highlight textbooks/study guides.<br>• Use supplementary materials.<br>• Give assistance in note taking<br>• Use adapted/modified textbooks.<br>• Allow use of computer/word processor.<br>• Allow student to answer orally, give extended time (time-and-a-half).<br>• Allow tests to be given in a separate location (with the ESL teacher).<br>• Allow additional time to complete assignments and/or assessments.<br>• Read question to student to clarify.<br>• Provide a definition or synonym for words on a test that do not impact the validity of the exam.<br>• Modify the format of assessments.<br>• Shorten test length or require only selected test items.<br>• Create alternative assessments.<br>• On an exam other than a spelling test, don’t take points off for spelling errors. |

**RAHWAY PUBLIC SCHOOLS CURRICULUM**

## *UNIT OVERVIEW*

**Content Area:** Advanced Robotics and Control Systems

**Unit Title:** Unit 1 - Basic Lego Robotics Code and Design

**Target Course/Grade Level:** 9-12

**Unit Summary:** This unit will serve as a reintroduction to the Lego Mindstorms robotic kits and how they are programmed. Students will use the Lego EV3 code program to use waits, loops, switches, and sensors to control basic robot movement. Basic code prompts and demonstrations will be used to support logical thinking and program design. Student led discussions will analyze teacher made Lego robots and determine their functionality.

**Approximate Length of Unit: About 6 Weeks**

## *LEARNING TARGETS*

**NJ Student Learning Standards:**

- 8.2.12.C.4 Explain and identify interdependent systems and their functions.
- 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).
- .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

**21st Century Life and Career Skills:**

- 9.3.ST.1 Apply engineering skills in a project that requires project management, process control and quality assurance
- 9.3.ST.3 Describe and follow safety, health and environmental standards related to science, technology, engineering and mathematics (STEM) workplaces.
- 9.3.ST.6 Demonstrate technical skills needed in a chosen STEM field.

**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.

**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).

**Unit Understandings:**

*Students will understand that…*

- robots consist of both hardware and software
- software controls what a robot does
- code allows the robot to use components like motors and sensors
- codes and programs follow an order of operation
- loops can allow a robot to repeat a process without adding additional code
- Lego beams, axles, and connectors each have their own specific use for building robots

**Unit Essential Questions:**

- How does a robots form limit its capabilities?
- How can touch sensors be used to control a robot autonomously?
- How does code influence and control a robot's actions?
- Why are loops essential for coding a robot?
- How can robots be programmed in picture based code language?

**Knowledge and Skills:**

*Students will know…..*

- the use and location of the following parts:
    - Beams
    - Axles
    - Motors
    - Touch Sensors
    - Connectors
- how robots are formed by hardware and software
- how basic code functions run (order of operations)
- the use of the following code segments:
    - Wait
    - Loop
    - Switch
    - Move-Steering

**Performance Expectations:**

*Students will be able to …*

- identify the use of each major part category
- build a simple robot that is able to move and turn
- construct a basic code to upload onto a teacher designed robot
- create a code that allows a robot to react to physical objects in its environment

## *EVIDENCE OF LEARNING*

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

- Worksheets
- Note sheets
- Participation (weekly)
- Practice code problems
- **End of Unit Quiz**
    - Students will identify parts and their uses and justify design choices of given examples.
    - Students will create a code that allows a robot to react to objects in its environment.

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

- Group build projects
- Teacher demonstrations over screencast
- Reinforcement worksheets and extra practice
- Code challenges
- Individualized student to teacher code demonstrations

## *RESOURCES*

**Teacher Resources:**

- Teacher designed presentations
- Teacher designed worksheets
- Teacher developed design challenges
- Lego EV3 video tutorials
- Teacher developed building instruction guides

**Equipment Needed:**

- Lego Mindstorms robotics kits
- Classroom computers

**RAHWAY PUBLIC SCHOOLS CURRICULUM**

## *UNIT OVERVIEW*

**Content Area:** Advanced Robotics and Control Systems

**Unit Title:** Unit 2 - Structural Stability in Robot Design

**Target Course/Grade Level:** 9-12

**Unit Summary:** This unit will focus on how parts can be connected together to form secure joints. Students will learn how to cut and securely connect aluminum beams to create a physical structure. Prior to machine usage the students will observe several machine shop safety lessons to ensure the machines are used in their safe and intended manner. Students will also learn how to create stable structures out of the Lego robotics materials.

**Approximate Length of Unit: About 5 Weeks**

## *LEARNING TARGETS*

**NJ Student Learning Standards:**

- 8.2.12.D.5 Explain how material processing impacts the quality of engineered and fabricated products.
- 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.B.2 Evaluate ethical considerations regarding the sustainability of environmental resources that are used for the design, creation and maintenance of a chosen product.
- 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).

**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.3 Describe and follow safety, health and environmental standards related to science, technology, engineering and mathematics (STEM) workplaces.
- 9.3.ST.6 Demonstrate technical skills needed in a chosen STEM field.

**Interdisciplinary Connections and Standards:**

- 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.

- G-SRT-C8 Use trigonometric ratios and the Pythagorean Theorem to solve right triangles in applied problems.

**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.

**Unit Understandings:**

*Students will understand that…*

- multiple connection points are needed to hold parts together securely
- a stable base is necessary for almost all robots
- shop machines have strict processes that need to be followed to operate them
- safety glasses are mandatory when working in the shop
- support beams and connection points allow robots to be built up while remaining structurally stable

**Unit Essential Questions:**

- Why do robots need a base?
- What makes a functional robot base?
- How can an unstable robot be made more secure?
- What are the essential safety procedures for operating machines in the metal shop?
- What is the best method for cutting precise perpendicular aluminum beams?
- What is the difference between bolts and screws?
- How can supports and extra connections increase robot durability?

**Knowledge and Skills:**

*Students will know…..*

- the safety procedures for:
    - operating the miter saw
    - operating the drill press
    - working in the metal shop (general)
    - using hand tools
- common robotics materials and the best method for altering them
- the process for attaching basic aluminum structures
- the benefit of brackets and other connector parts

**Performance Expectations:**

*Students will be able to …*

- safely use  a miter saw, drill press, and power drills
- assemble a basic aluminum from to teacher set dimensions
- accurately measure and cut aluminum and wood
- create a supportive base using Lego robotics materials
- analyze a model robot structure and determine how it could be improved

## *EVIDENCE OF LEARNING*

**Assessment:**

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

- Worksheets
- Note sheets
- Participation (weekly)
- Safety quizzes
- **End of Unit Assessment:** Independent projects and skill demonstrations
    - Students will use a miter saw, drill press, and power drills appropriately.
    - Students will evaluate a model robot structure and determine how it could be improved.

**Learning Activities:**

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

- Machine presentations and demonstrations
- Practice machine shop builds
- One on one practice sessions for each shop machine
- Review sessions on safety materials
- Stable robot base design (Lego)
- Force simulator demonstrations

## *RESOURCES*

**Teacher Resources:**

- Teacher designed presentations
- Teacher designed worksheets
- Teacher developed design challenges
- Teacher developed building instruction guides
- Teacher designed safety information sheets, presentations, and quizzes

**Equipment Needed:**

- Lego Mindstorms robotics kits
- Classroom computers
- Aluminum 1x1 beams
- Miter saw
- Drill press
- Measurement tools
- Power drills

**RAHWAY PUBLIC SCHOOLS CURRICULUM**

## *UNIT OVERVIEW*

**Content Area:** Advanced Robotics and Control Systems

**Unit Title:** Unit 3 - Software and Programming

**Target Course/Grade Level:** 9-12

**Unit Summary:** In this unit students will learn how to take the conceptual knowledge of code and apply it to a formal code language. Students will learn the basic elements of Javascript and how it can be used to control a robot. Javascript will be used to program basic movement and simple environmental reactions.

**Approximate Length of Unit: About 6 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.4 Explain and identify interdependent systems and their functions.
- 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.

**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.
- 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.

**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.9-10.8. Determine if the reasoning and evidence in a text support the author's claim or a recommendation for solving a scientific or technical problem

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

**Unit Understandings:**
*Students will understand that…*

- Javascript is an entry level text code language
- functions are miniature programs used to make code more controlled and effcient
- different code languages use different terminology but function in similar ways
- If, while, and for loops allow robots to react to environmental inputs

**Unit Essential Questions:**

- Why is Javascript superior to picture-based coding?
- How can code be condensed through functions?
- What are the similarities and differences between Javascript and EV3?
- How can a robot react to running into an object?
- What does it mean for a robot to truly be autonomous?
- How do loops shape code?
- What are variables and how are they used in Javascript?

**Knowledge and Skills:**
*Students will know…..*

- the differences and similarities between Javascript and EV3 programming
- the syntax of Javascript
- the proper format for Lego Javascript code
- the movement function and its parameters
- the uses of if, while, and for loops in Javascript
- the use of Boolean variables in Javascript

**Performance Expectations:**
*Students will be able to …*

- develop basic movement codes using Javascript
- adjust movement code parameters to navigate a set course
- use variables to allow a robot to react to its environment
- use for loops to have robots repeat a process a set amount of time
- create basic functions with code programs

## *EVIDENCE OF LEARNING*

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

- Worksheets
- Code examples
- Note sheets
- Participation (weekly)
- **End of Unit Quiz**
    - Students will create movement codes using Javascript.
    - Students will adjust movement code parameters to navigate a course.
    - Students will create basic functions with code programs.

**Learning Activities:**

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

- Practice code examples
- Practice "debugging" teacher designed code
- Independent code practice
- Advanced example problems for accelerated students

## *RESOURCES*

**Teacher Resources:**

- Teacher designed presentations
- Teacher designed worksheets
- Teacher developed design challenges
- Teacher developed building instruction guides
- Teacher developed Javascript definitions sheet

**Equipment Needed:**

- Lego Mindstorms robotics kits
- Classroom computers

**RAHWAY PUBLIC SCHOOLS CURRICULUM**

## *UNIT OVERVIEW*

**Content Area:** Advanced Robotics and Control Systems

**Unit Title:** Unit 4 - Mechanical Systems

**Target Course/Grade Level:** 9-12

**Unit Summary:** In this unit students will learn about mechanical systems and devices used to control robot movement and functionality. Motors, the most popular method of robotic movement, rely on gear boxes and gear ratios to operate. Students will examine gear ratios and their effects. Students will learn about driving linear and rotational motion.

**Approximate Length of Unit: About 5 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.C.3 Analyze a product or system for factors such as safety, reliability, economic considerations, quality control, environmental concerns, manufacturability, maintenance and repair, and human factors engineering (ergonomics).
- 8.2.12.C.4 Explain and identify interdependent systems and their functions
- 8.2.12.E.2 Analyze the relationships between internal and external computer components.

**21st Century Life and Career Skills:**

- 9.3.ST.1 Apply engineering skills in a project that requires project management, process control and quality assurance.
- 9.3.ST.3 Describe and follow safety, health and environmental standards related to science, technology, engineering and mathematics (STEM) workplaces.
- 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.

**Interdisciplinary Connections and Standards:**

- 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.

**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.9-10.7. 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…*

- parts can come together to form mechanisms that serve specific purposes
- motors create rotational motion
- gears can be used to increase the power or speed of a motor's output
- pulleys, chains, and gears can be used to transfer motion
- mechanisms typically have a set range of motion

**Unit Essential Questions:**

- How can motors produce both rotational and linear movement?
- How do gearboxes amplify motor output?
- What are the advantages of high gear ratios?
- What is the relationship between speed and force in terms of motor output?

**Knowledge and Skills:**

*Students will know…..*

- the difference between rotational and linear motion
- the effect low and high gear ratios have on motor output
- how to calculate gear ratio
- how chains and pulleys are used to transfer motion

**Performance Expectations:**

*Students will be able to …*

- calculate gear ratios of given gear combinations
- construct gearboxes with classroom materials
- design and construct a robot that utilizes gears to enhance motor output
- construct a robot that uses both linear motion and rotational motion
- utilize chains and belts to transfer movement within a robot

## *EVIDENCE OF LEARNING*

**Assessment:**

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

- Worksheets
- Design-Build Challenges
- Note sheets
- Participation (weekly)
- **End of Unit Quiz**
    - Students will design and construct a robot that utilizes gears to enhance motor output.

- Students will observe both picture and physical examples of teacher made mechanisms and analyze their design and purpose.

**Learning Activities:**

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

- Mechanical systems stations demonstration
- Practice mechanical system builds
- Class presentations on mechanisms and their functions
- Group design projects
- Class discussions about the mechanisms used for FRC robots

## *RESOURCES*

**Teacher Resources:**

- Teacher designed presentations
- Teacher designed worksheets
- Teacher developed design challenges
- Teacher developed building instruction guides
- Teacher developed Javascript definitions sheet
- Teacher developed example mechanical systems

**Equipment Needed:**

- Lego Mindstorms robotics kits
- Classroom computers

**RAHWAY PUBLIC SCHOOLS CURRICULUM**

## *UNIT OVERVIEW*

**Content Area:** Advanced Robotics and Control Systems

**Unit Title:** Unit 5 - Sensors and Automation

**Target Course/Grade Level:** 9-12

**Unit Summary:** Sensors are used to help robots receive information (inputs) from their environment in order to react (output). Students will learn about each of the available sensors (gyro, touch, sound, and ultrasonic) and what specific factor they measure. In Javascript the sensor values can be used to alter variables and create robot reactions. Throughout this unit students will solve a series of code challenges to make robots behave autonomously.

**Approximate Length of Unit: About 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.4 Explain and identify interdependent systems and their functions.
- 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.E.2 Analyze the relationships between internal and external computer components.
- 8.2.12.A.3 Research and present information on an existing technological product that has been repurposed for a different function.

**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.5 Apply the knowledge learned in STEM to solve problems.

**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-ETS1-3. 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.

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

- 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.
- 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.

**Unit Understandings:**

*Students will understand that…*

- sensors measure specific aspects of their environment
- data from sensors can be used to influence code and robot actions
- comparisons allow variables and data to influence if, while, and for loops
- sensors need to be calibrated
- code takes inputs (user or environment) and generate an output

**Unit Essential Questions:**

- How do robots sense aspects of their environment?
- How can code programs accommodate inaccurate sensors?
- What makes a sensor appropriate for a robot?
- How are limit switches used to control movement?
- How do sensors give robots an appearance of intelligence?

**Knowledge and Skills:**

*Students will know…..*

- the purpose and use of the following sensors:
    - Ultrasonic
    - Touch
    - Sound
    - Gyro
- the units used by each sensor
- the difference between analog and digital data
- the definition of threshold values

**Performance Expectations:**

*Students will be able to …*

- create Javascript code that allows a robot to react to object distances in its environment
- create Javascript code that uses gyro sensors to move accurately
- compare and contrast the benefits of the available sensors
- select appropriate sensors based on measured data type
- create and program a robot that uses sensors to function autonomously
- modify and fix flawed code
- analyze real world robots to determine how sensors are used
- utilize multiple sensors to create complex autonomous behavior
- synthesize code programs that use functions to create autonomous robots

## *EVIDENCE OF LEARNING*

**Assessment:**

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

- Worksheets
- Design-Build Challenges
- Note sheets
- Participation (weekly)
- **End of Unit Quiz**
    - Students will identify sensors, explain what they measure, and how a robot can use them.
    - Students will analyze real-world robots to explain how sensors are used.

**Learning Activities:**

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

- Sensor demonstrations and class discussions
- Miniature code activities
- Group projects
- Class discussions on "real world" robots and sensor usage
- Station activities for exploring sensors and how they work

## *RESOURCES*

**Teacher Resources:**

- Teacher designed presentations
- Teacher designed worksheets
- Teacher developed design challenges
- Teacher developed building instruction guides
- Teacher developed Javascript definitions sheet
- Roomba functionality video

**Equipment Needed:**

- Lego Mindstorms robotics kits
- Classroom computers

**RAHWAY PUBLIC SCHOOLS CURRICULUM**

## *UNIT OVERVIEW*

**Content Area:** Advanced Robotics and Control Systems

**Unit Title:** Unit 6 - Robot Design and Functionality

**Target Course/Grade Level:** 9-12

**Unit Summary:** A robot's physical form can allow it function and adapt to its environment. When designing a robots physical form it is important to take into account how it will be used and where it will be used. Students will learn about designing robots based on factors like terrain, climate, and purpose. Students will design robots that can handle given environmental terrain and still function normally. Design projects and teacher examples will be heavily relied on to demonstrate the effects of difference robot base designs. Students will also learn about factors like wire management and material usage when creating robots. Projects will be evaluated in terms of functionality, safety, and material usage.

**Approximate Length of Unit: About 5 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.C.3 Analyze a product or system for factors such as safety, reliability, economic considerations, quality control, environmental concerns, manufacturability, maintenance and repair, and human factors engineering (ergonomics).
- 8.2.12.C.4 Explain and identify interdependent systems and their functions.
- 8.2.12.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.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.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

**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-ETS1-3. 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.

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

- 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…*

- different terrain requires adaptive and appropriate movement systems
- friction and contact points are necessary for a wheel driven robot to traverse its environment
- tire thickness and material can affect a robot's ability to move
- the lowest amount of material should be used when building a robot in order to reduce cost and effect on the environment
- wheel and motor layout can affect a robot's overall traction and control

**Unit Essential Questions:**

- How do modern cars handle a variety of terrains?
- How do tire sizes affect traction and robot speed?
- What is traction and how can traction be increased for drive systems?
- Why is it important to limit part usage when building a robot?
- How does wheel and motor layout affect a robot's ability to drive and turn?
- How does weight distribution affect a robot's balance on uneven terrain?

**Knowledge and Skills:**

*Students will know…..*

- the definition of friction, traction, and weight distribution
- how modern cars adapt to terrain
- the relationship between wheel layout and robot maneuverability
- the effect of a robot's weight distribution when in motion
- the relationship between tire friction and overall traction

**Performance Expectations:**

*Students will be able to …*

- design robots to cross rough terrain
- design robots to climb steep inclines
- compare the benefits if different drive base layouts
- analyze and correct ineffective robots in terms of drive operation

- utilize wheels, treads, and legs when driving robot motion
- analyze a robot to reduce waste parts and increase material efficiency
- design a drive base that can be modified for a variety of design challenges
- analyze real world robots in terms of design, functionality, and safety

## *EVIDENCE OF LEARNING*

**Assessment:**

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

- Worksheets
- **Design-Build Challenges Assessment:**
  - Students will work together to build a robot capable of traversing uneven terrain. The robot will be designed by the students and should utilize design techniques discussed in class.
- Note sheets
- Participation (weekly)
- Group projects

**Learning Activities:**

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

- Class discussions
- Independent design challenges
- Group design challenges
- Teacher made example robot analysis

## *RESOURCES*

**Teacher Resources:**

- Teacher designed presentations
- Teacher designed worksheets
- Teacher developed design challenges
- Teacher developed example robots

**Equipment Needed:**

- Lego Mindstorms robotics kits
- Classroom computers

**RAHWAY PUBLIC SCHOOLS CURRICULUM**

## *UNIT OVERVIEW*

**Content Area:** Advanced Robotics and Control Systems

**Unit Title:** Unit 7 - Problem Solving Using Robotics

**Target Course/Grade Level:** 9-12

**Unit Summary:** Robots are used to make the lives of humans easier. Through intelligent robot design humans can automate processes and reduce human labor needs. In this unit students will explore several complex design activities in which student groups will need to design robots to autonomously function as needed. Students will need to analyze design briefs, plan solutions, build and test prototypes, and evaluate for effectiveness. The design challenges will range from simple tasks to complex tasks that require multiple sensors, motors, and mechanisms to function properly.

**Approximate Length of Unit: About 5 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.E.4 Use appropriate terms in conversation (e.g., troubleshooting, peripherals, diagnostic software, GUI, abstraction, variables, data types and conditional statements).
- 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.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).

**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-ET.5 Apply the knowledge learned in STEM to solve problems.

**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-ETS1-3. 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.

**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.9-10.7. 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…*

- design constraints, specifications, and limitations shape how a robot should be designed
- a robot's form needs to support its function
- both code and robot form need to interact for a robot to perform complex tasks
- autonomous robots need to interact with the environment to function
- robots are made up of subsystems
- subsystems can be mapped out to expedite the design process

**Unit Essential Questions:**

- What makes a robot's design appropriate for its function?
- How can multiple sensors and motors interact to perform complex autonomous motion?
- Why is it beneficial for a robot to operate autonomously?
- Why is it important to create quantifiable tests for prototypes?
- How can a robot be deemed functional?
- How can a robot be broken down into subsystems? What are the benefits of this method?

**Knowledge and Skills:**

*Students will know…..*

- the engineering design process
- the definitions of subsystems, constraints, limitations, and specifications
- the relationship between subsystems
- the relationship between robot form and function
- the benefits and faults with robot automation
- the effect of robot automation on the world

**Performance Expectations:**

*Students will be able to …*

- collaborate with peers
- synthesize prototype robots based on design constraints
- design autonomous robots that are capable of:
    - moving objects
    - performing repetitive tasks
    - lifting objects
    - climbing over obstacles/crossing wide gaps
    - navigating through mazes while performing additional tasks
- determine necessary parts and mechanisms based on given tasks
- combine sensors and motors to create complex autonomous functionality

- defend and debate design decisions
- analyze and evaluate robots in terms of functionality, limitations, and purpose
- redesign robots to improve overall effectiveness

## *EVIDENCE OF LEARNING*

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

- Worksheets
- **Design-Build Challenges Assessments:**
  - Students will work in teams to design, build, and code a robot to complete the design goal.
  - Students will create an object sorter.
  - Students will create a maze solving robot.
- Participation (weekly)

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

- Class discussions
- Independent design challenges
- Group design challenges
- Station activities on mechanical systems
- Teacher made examples and demonstrations
- Additional project challenges/requirements for accelerated students

## *RESOURCES*

**Teacher Resources:**

- Teacher designed presentations
- Teacher designed worksheets
- Teacher developed design challenges
- Teacher developed example robots

**Equipment Needed:**

- Lego Mindstorms robotics kits
- Classroom computers

**RAHWAY PUBLIC SCHOOLS CURRICULUM**

## *UNIT OVERVIEW*

**Content Area:** Advanced Robotics and Control Systems

**Unit Title:** Unit 8 - User Robot Control

**Target Course/Grade Level:** 9-12

**Unit Summary:** While it is beneficial for a robot to operate autonomously, sometimes robots need to be directly controlled by a user. The operator is responsible for giving robots appropriate input to determine robot output. Students will explore the design of joysticks, game controllers, and smartphone applications. Students will develop controllers, utilize premade controllers, and design applications to control classroom robots.

**Approximate Length of Unit: About 4 Weeks**

## *LEARNING TARGETS*

**NJ Student Learning Standards:**

- 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.C.1 Explain how open source technologies follow the design process.
- 8.2.12.B.3 Analyze ethical and unethical practices around intellectual property rights as influenced by human wants and/or needs.
- 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.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.

**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.

**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…*

- users are capable of supplying data input to robots
- user controls robots to be easily adjusted and more reactive to their environment
- data can be used to control a robot through physical integration (controllers) and wireless integration (applications)
- applications can send commands through Bluetooth and WiFi
- separate programs need to be developed in order to control a robot through an application

**Unit Essential Questions:**

- What are the advantages of controlling a robot through a control device?
- How is data sent to and received by a robot?
- How can applications be designed through web browser design software?
- How can wireless devices connect to each other over Bluetooth and WiFi?
- How does physical application layout enhance robot control?
- How do joysticks and game controllers measure user input?

**Knowledge and Skills:**

*Students will know…..*

- several examples of user control devices and how they work
- how data can be sent from one device to another
- the benefits and faults with user control
- the limitations of control devices like joysticks, controllers, and applications
- the difference between wired, Bluetooth, and WiFi connections

**Performance Expectations:**

*Students will be able to …*

- design robots that are capable of moving and operating based on user control
- generate applications to send input data to a robot
- synthesize robot programs that use user input to influence Javascript functions
- solve design challenges through the production of user controlled robots
- compare and contrast the benefits of user and autonomous control

## *EVIDENCE OF LEARNING*

**Assessment:**

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

- Worksheets
- Design-Build Challenges
  - Students will design both a robot and app to control the robot through MIT App Inventor.
  - Each robot will participate in an arena style competition where certain tasks need to be completed.
  - Robots will need to utilize claws, arms, and other mechanisms.
- Participation (weekly)

**Learning Activities:**

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

- Class discussions
- Independent design challenges
- Group design challenges
- Teacher made examples and demonstrations
- Program design tutorials over teacher screen cast
- Additional project challenges/requirements for accelerated students

## *RESOURCES*

**Teacher Resources:**

- Teacher designed presentations
- Teacher designed worksheets
- Teacher developed design challenges
- Teacher developed example robots
- Teacher developed App Inventor tutorial guides

**Equipment Needed:**

- Lego Mindstorms robotics kits
- Classroom computers
- Recycled smart phones / student phones