Randolph Township Schools
Randolph Middle School
Robotics I Curriculum

"At bottom, robotics is about us. It is the discipline of emulating our lives, of wondering how we work."

-Rod Grupen

STEM Department

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September 21, 2021

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Mission Statement

We commit to inspiring and empowering all students in Randolph schools to reach their full potential as unique, responsible and educated members of a global society.

Affirmative Action Statement
Equality and Equity in Curriculum

The Randolph Township School district ensures that the district's curriculum and instruction are aligned to the state's standards. The curriculum provides equity in instruction, educational programs and provides all students the opportunity to interact positively with others regardless of race, creed, color, national origin, ancestry, age, marital status, affectional or sexual orientation, gender, religion, disability or socioeconomic status.

N.J.A.C. 6A:7-1.7(b): Section 504, Rehabilitation Act of 1973; N.J.S.A. 10:5; Title IX, Education Amendments of 1972

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EDUCATIONAL GOALS
VALUES IN EDUCATION

The statements represent the beliefs and values regarding our educational system. Education is the key to self-actualization, which is realized through achievement and self-respect. We believe our entire system must not only represent these values, but also demonstrate them in all that we do as a school system.

We believe:

- The needs of the child come first
- Mutual respect and trust are the cornerstones of a learning community
- The learning community consists of students, educators, parents, administrators, educational support personnel, the community and Board of Education members
- A successful learning community communicates honestly and openly in a non-threatening environment
- Members of our learning community have different needs at different times. There is openness to the challenge of meeting those needs in professional and supportive ways
- Assessment of professionals (i.e., educators, administrators and educational support personnel) is a dynamic process that requires review and revision based on evolving research, practices and experiences
- Development of desired capabilities comes in stages and is achieved through hard work, reflection and ongoing growth

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Introduction

Robotics I is a marking period course that fulfills New Jersey requirements for computer science and design thinking. In this class students will learn the basics of computer science and learn to apply them to robotics. Computer scientists use computational thinking to solve problems, write programs, and complete complex tasks. In the first unit, students will learn the basics of computers science focusing on how a computer works, binary code, and networking. In the second unit, students will learn the foundation of robotics by building and coding a Lego Ev3 robot to solve real-world problems. Students will learn how to create algorithms, conditional statements, variables, and Boolean statements in their code. The final unit of this course will integrate computational thinking and design thinking through an authentic learning experience using robotics to build a more sustainable technology. By the end of this course, students will have gained important computer science and design thinking skills relevant to their current and future endeavors in academics, computing, and society. This course will be guided by the current New Jersey Learning Standards in Computer Science and Design Thinking, Science, Mathematics, and English.

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Curriculum Pacing Chart

SUGGESTED TIME ALLOTMENT	UNIT NUMBER	CONTENT - UNIT OF STUDY
2 weeks	I	Computer Science Principles
3 weeks	II	Computational Thinking with Robotics
4 weeks	III	Sustainable Solutions with Robotics

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Unit I: Computer Science Principles

TRANSFER: Students will be able to mobilize the engineering design process and domain knowledge to create an original model given limitations and constraints.		
STANDARDS / GOALS:	**ENDURING UNDERSTANDINGS**	**ESSENTIAL QUESTIONS**
NJ 2020 SLS: Computer Science and Design Thinking 8.1.8.CS.1: Recommend improvements to computing devices in order to improve the ways users interact with the devices. 8.1.8.DA.2: Explain the difference between how the computer stores data as bits and how the data is displayed. 8.1.8.DA.3: Identify the appropriate tool to access data based on its file format. 8.1.8.IC.1: Compare the trade-offs associated with computing technologies that affect individual's everyday activities and career options.	People interact with a wide variety of computing devices that collect, store, analyze, and act upon information in ways that can affect human capabilities both positively and negatively.	• How can computational thinking change the way we solve problems?
	Data is collected and stored so that it can be analyzed to better understand the world and make more accurate predictions.	• How does the way we use and organize data change as technology and society advance?
	Networks connect computing devices to share information and resources and are an increasingly integral part of computing.	• How does sharing information change the way we interact?
	<u>KNOWLEDGE</u> **Students will know:**	**<u>SKILLS</u>** **Students will be able to:**
	Computers require a system for storing information that is reliable and fast such as a binary system.	Describe how a binary system represents information using just two possible states.

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Unit I: Computer Science Principles

8.1.8.IC.2: Describe issues of bias and accessibility in the design of existing technologies.		Model how binary is used in computing with a physical object that has two states, such as a light.
8.1.8.NI.1: Model how information is broken down into smaller pieces, transmitted as addressed packets through multiple devices over networks and the Internet, and reassembled at the destination. 8.1.8.NI.2: Model the role of protocols in transmitting data across networks and the Internet and how they enable secure and errorless communication.	Software tools translate the low-level representation of bits into a form understandable by individuals.	Identify the appropriate tool to access data based on its file format. Describe the difference between how the computer stores data as bits and how the data is displayed. Create and manipulate binary patterns to represent black and white images and ASCII characters.
8.1.8.NI.3: Explain how network security depends on a combination of hardware, software, and practices that control access to data and systems. 8.1.8.NI.4: Explain how new security measures have been created in response to key malware events.	The study of human–computer interaction can improve the design of devices and extend the abilities of humans.	List computer interactions that improve everyday life. Recommend improvements to computing devices, apps, software, or code, in order to improve the ways users interact with it.
8.2.8.ITH.1: Explain how the development and use of technology influences economic, political, social, and cultural issues.	Society is faced with trade-offs due to the increasing globalization and automation that computing brings.	Describe issues of bias and accessibility in the design of existing technologies.

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Unit I: Computer Science Principles

8.2.8.ITH.2: Compare how technologies have influenced society over time. **NJ 2016 SLS: Literacy in History, Social Studies, & Technical Subjects** RST.6-8.4: Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 6-8 texts and topics. **NJ 2016 SLS: Mathematical Practices** MP1: Make sense of problems and persevere in solving them. MP2: Reason abstractly and quantitatively. MP4: Model with mathematics. MP5: Use appropriate tools strategically.	Technology and society interact with and affect each other as societal needs drive development of new technological products, and new technology influences human social behavior. Protocols, packets, and addressing are the key components for reliable delivery of information across networks.	Analyze the trade-offs associated with computing technologies that affect individual's everyday activities and career options. Identify the origin and purpose of a technology, such as the Internet, and how its technical structure and design contributes to a social dilemma. Analyze how the development and use of technology influences economic, political, social, and cultural issues. Define the role of addressing, protocols, and packets in computer networking. Illustrate how computing devices can be connected to form a network. Demonstrate how packet numbering and re-ordering can allow for large messages to reliably be sent even if packets are dropped or arrive out of order.

Unit I: Computer Science Principles

		Model the role of TCP and UDP protocols in transmitting data across networks and the Internet and how they enable secure and errorless communication.
	The information sent and received across networks can be protected from unauthorized access and modification in a variety of ways.	Analyze how network security depends on a combination of hardware, software, and practices that control access to data and systems.
	The evolution of malware leads to understanding the key security measures and best practices needed to proactively address the threat to digital data.	Investigate how new security measures have been created in response to key malware events.
	VOCABULARY: technology, data, trade-off, bias, accessibility, security **KEY TERMS:** computing, computational thinking, binary, file format, network, packets, protocol, hardware, software, malware	

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Unit I: Computer Science Principles

ASSESSMENT EVIDENCE: Students will show their learning by:

- Reflecting on present and past learning through prompts in a OneNote journal
- Manipulating binary code to produce digital artifacts
- Creating a digital product to represent the correlation between technology and society
- Demonstrating data transmission and security through networking using a representative model

KEY LEARNING EVENTS AND INSTRUCTION:

- Students will model binary code in an online simulator
- Students will research how they interact with technology and how some technology is biased or not equitable
- Students will model how information is sent across networks in packets
- Students will investigate network security and how it evolves over time due to security breaches

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Unit I: Computer Science Principles

SUGGESTED TIME ALLOTMENT	**2 weeks**
SUPPLEMENTAL UNIT RESOURCES	Required Supplies/Activities/Software: Computers with Internet access Microsoft OneNote Suggested Supplies/Activities/Software: https://curriculum.code.org/csp-20/unit2/ "Building a Network" "Packets" https://studio.code.org/courses/csd-2021?section_id=3071346 "Binary"

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Unit II: Computational Thinking with Robotics

<table>
<tr><td colspan="3">TRANSFER: Students will be able to mobilize the engineering design process and domain knowledge to create an original model given limitations and constraints.</td></tr>
<tr><td rowspan="5">STANDARDS / GOALS:

NJ 2020 SLS: Computer Science and Design Thinking
8.1.8.AP.1: Design and illustrate algorithms that solve complex problems using flowcharts and/or pseudocode.

8.1.8.AP.2: Create clearly named variables that represent different data types and perform operations on their values.

8.1.8.AP.3: Design and iteratively develop programs that combine control structures, including nested loops and compound conditionals.

8.1.8.AP.4: Decompose problems and sub-problems into parts to facilitate the design, implementation, and review of programs.</td><td>ENDURING UNDERSTANDINGS</td><td>ESSENTIAL QUESTIONS</td></tr>
<tr><td>Computational thinking is a universal problem-solving approach used to solve problems while thinking like a computer scientist.</td><td>• How can you solve a problem?</td></tr>
<tr><td>Algorithms and programming control all computing systems, empowering people to communicate with the world in new ways and solve compelling problems.</td><td>• How can the design of an algorithm help describe the function that it performs?</td></tr>
<tr><td><u>KNOWLEDGE</u>
Students will know:</td><td><u>SKILLS</u>
Students will be able to:</td></tr>
<tr><td>Computational thinking is a framework of problem-solving using decomposition, pattern matching, abstraction, and algorithms.</td><td>Describe the four pillars of computational thinking.

Apply computational thinking strategies to everyday problem-solving, including robotics programming.</td></tr>
</table>

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Unit II: Computational Thinking with Robotics

8.1.8.AP.5: Create procedures with parameters to organize code and make it easier to reuse.	Pseudocode is the first step in programming used to help understand the constraints of a problem.	Design pseudocode to instruct a robot to complete a task, such as directional movement.
8.1.8.CS.4: Systematically apply troubleshooting strategies to identify and resolve hardware and software problems in computing systems.	Programs use procedures to organize code and hide implementation details.	Construct pseudocode and programs in an organized fashion so they can be reused.
8.1.8.DA.5: Test, analyze, and refine computational models.	Procedures can be repurposed in new programs.	Create a programming library that can be reused in the future to help solve other problems.
8.2.8.NT.1: Examine a malfunctioning tool, product, or system and propose solutions to the problem.	Coding can be used to have a robot perform a specific task.	Develop code to have a robot move forward, backward, and turn.
8.2.8.NT.2: Analyze an existing technological product that has been repurposed for a different function.	Robots can collect data concerning length, temperature, light, color, touch and other conditions.	Program a robot to perform a task based upon data received from input such as the touch button, ultrasonic, or color sensor.
8.2.8.NT.3: Examine a system, consider how each part relates to other parts, and redesign it for another purpose.	Technology developed for one purpose can be adapted to serve other purposes, advancing the field through innovation and invention.	Describe how each part relates to other parts in a robotics system.
8.2.8.NT.4: Explain how a product designed for a specific demand was modified to meet a new demand and led to a new product.		

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NJ 2016 SLS: Literacy in History, Social Studies, & Technical Subjects RST.6-8.3: Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks. RST.6-8.4: Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 6-8 texts and topics. RST.6-8.7: Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table). **NJ 2016 SLS: Mathematical Practices** MP1: Make sense of problems and persevere in solving them. MP2: Reason abstractly and quantitatively. MP4: Model with mathematics. MP5: Use appropriate tools strategically. MP7: Look for and make use of structure.	Defining parameters for procedures can generalize behavior and increase reusability and reliability. Complex problems can be decomposed into efficient algorithms by organizing code to generalize behavior and increase reusability. Readable algorithms can be reused in many situations and are easier to follow, test, and debug. Control structures like conditional if-else statements and loops are selected and combined in programs to solve more complex problems. Programmers create variables to store data values of different types and perform appropriate operations on their values.	Repurpose an existing robot to solve a design challenge. Identify the constraints and parameters of the code needed to solve a robotics design problem. Decompose problems and sub-problems into parts to design a more efficient algorithm. Develop efficient algorithms that combine to solve a complex robotics problem. Organize code using control structures to more efficiently perform a task. Code software that will store a variable, then retrieve it later for processing.

Unit II: Computational Thinking with Robotics

MP8: Looking for and expressing regularity in repeated reasoning.	Troubleshooting a problem is more effective when knowledge of the specific device along with a systematic process is used to identify the source of a problem.	Systematically apply troubleshooting strategies to identify and resolve hardware and software problems in a robot. Determine the source of a malfunction in a robot and propose solutions to the problem.
	VOCABULARY: software, Bluetooth, design, procedures, troubleshooting, efficient, developing, building, testing, reflection, criteria, constraints **KEY TERMS:** computational thinking, decomposition, pattern recognition, algorithm, abstraction, pseudocode, conditional statement, function, loop, if then, Boolean statement	

Unit II: Computational Thinking with Robotics

ASSESSMENT EVIDENCE: Students will show their learning by:

- Reflecting on present and past learning through prompts in a OneNote journal
- Designing algorithms in programing for a robot to complete a task
- Constructing efficient programs to meet the criteria for a robot to complete a task

KEY LEARNING EVENTS AND INSTRUCTION:

- Students will build and program a robot to navigate through an environment
- Students will program a robot to start, end, or perform a new task when a touch button is pressed
- Students will program a robot to navigate a maze using a color sensor
- Students will create a self-parking car using a touch button and multiple ultrasonic sensors

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Unit II: Computational Thinking with Robotics

SUGGESTED TIME ALLOTMENT	**3 Weeks**
SUPPLEMENTAL UNIT RESOURCES	Required Supplies/Activities/Software: Computers with Internet access Microsoft OneNote EV3 Lego Mindstorms Software Lego Mindstorms Robots Legos Suggested Supplies/Activities/Software: https://ev3lessons.com/en/ “Robot Baseball” “Touch Button” “Color Maze” “Self-Parking Car”

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Unit III: Sustainable Solutions with Robotics

<table>
<tr><td colspan="3">TRANSFER: Students will be able to mobilize the engineering design process and domain knowledge to create an original model given limitations and constraints.</td></tr>
<tr><td rowspan="6">STANDARDS / GOALS:

NJ 2020 SLS: Computer Science and Design Thinking
8.1.8.AP.6: Refine a solution that meets users' needs by incorporating feedback from team members and users.

8.1.8.AP.7: Design programs, incorporating existing code, media, and libraries, and give attribution.

8.1.8.AP.8: Systematically test and refine programs using a range of test cases and users.

8.1.8.AP.9: Document programs in order to make them easier to follow, test, and debug.</td><td>ENDURING UNDERSTANDINGS</td><td>ESSENTIAL QUESTIONS</td></tr>
<tr><td>The engineering design process allows engineers to move from finding "a" solution to finding "the best" solution to a problem.</td><td>• What makes a solution the best one?</td></tr>
<tr><td>The science and application of automation and robotics can be applied to protect the Earth's resources, environment, and society.</td><td>• How can technology change the world?</td></tr>
<tr><td><u>KNOWLEDGE</u>
Students will know:</td><td><u>SKILLS</u>
Students will be able to:</td></tr>
<tr><td>The development of technology is intended to make the completion of tasks easier, safer, and/or more efficient and can have positive and negative effects on the economy and environment.</td><td>Research and analyze the design of products that negatively impact the environment or society.</td></tr>
</table>

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Unit III: Sustainable Solutions with Robotics

8.1.8.CS.2: Design a system that combines hardware and software components to process data. 8.1.8.CS.3: Justify design decisions and explain potential system trade-offs. 8.2.8.EC.1: Explain ethical issues that may arise from the use of new technologies. 8.2.8.EC.2: Examine the effects of ethical and unethical practices in product design and development. 8.2.8.ED.1: Evaluate the function, value, and aesthetics of a technological product or system, from the perspective of the user and the producer. 8.2.8.ED.2: Identify the steps in the design process that could be used to solve a problem. 8.2.8.ED.3: Develop a proposal for a solution to a real-world problem that includes a model (e.g., physical prototype, graphical/technical sketch).	Resources need to be utilized wisely to have positive effects on the environment and society. The burning of fossil fuels has increased CO2 levels to record highs, but renewable energy can help mitigate CO2 gas production. Renewable energy like solar, wind, and geothermal do not consume earth's finite resources.	Brainstorm existing technologies and products that potentially can be improved or repurposed through modifying resources. Illustrate how a product is upcycled into a new product and analyze the short- and long-term benefits and costs. Identify how greenhouse gases affect the environment. Identify the positive effects of renewable energy. Compare the environmental effects of two alternative technologies devised to address climate change issues and recommend how robotics can improve them. Justify which alternative energy source is best.

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8.2.8.ED.4: Investigate a malfunctioning system, identify its impact, and explain the step-by-step process used to troubleshoot, evaluate, and test options to repair the product in a collaborative team. 8.2.8.ED.7: Design a product to address a real-world problem and document the iterative design process, including decisions made as a result of specific constraints and trade-offs (e.g., annotated sketches). 8.2.8.ETW.1: Illustrate how a product is upcycled into a new product and analyze the short- and long-term benefits and costs. 8.2.8.ETW.2: Analyze the impact of modifying resources in a product or system (e.g., materials, energy, information, time, tools, people, capital).	Renewable energy can have a negative impact on its environment. Engineering design requirements and specifications involve making trade-offs between competing requirements and desired design features. Autonomous robots aid in making the completion of tasks easier, safer, and more efficient.	Identify negative impacts renewable energy can have on its environment. Describe ethical issues that may arise in the design, development, and use of these technologies. Research ways that robotics can be used to mitigate negative effects of renewable energy. Develop a proposal using robotics to address a real-world problem to create a more sustainable outcome. Justify design decisions and explain potential system trade-offs in the design of your robot or coding. Design a functional robot to improve how a task is completed.

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8.2.8.ETW.3: Analyze the design of a product that negatively impacts the environment or society and develop possible solutions to lessen its impact. 8.2.8.ETW.4: Compare the environmental effects of two alternative technologies devised to address climate change issues and use data to justify which choice is best. 8.2.8.ITH.3: Evaluate the impact of sustainability on the development of a designed product or system. 8.2.8.ITH.4: Identify technologies that have been designed to reduce the negative consequences of other technologies and explain the change in impact. 8.2.8.ITH.5: Compare the impacts of a given technology on different societies, noting factors that may make a technology appropriate and sustainable in one society but not in another.	Robots improve productivity when they are applied to tasks that they perform more efficiently than humans. The design of the robot needs to consider the required task and needs of the users and the community. Robotics systems and programs should be tested regularly to identify errors and ensure functionality.	Analyze how robots can impact productivity of renewable energy. Compare the project's criteria and constraints to the design of the robot. Design programs, incorporating existing code, media, and libraries, and give attribution. Document programs in order to make them easier to follow, test, and debug. Systematically test and refine programs based on feedback using a range of test cases and users. Apply a step-by-step process to troubleshoot, evaluate and test a malfunctioning system.

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NJ 2020 SLS: Science MS-ESS3-3: Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment. MS-ESS3-5: Ask questions to clarify evidence of the factors that have caused climate change over the past century. ETS1-1: Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions. MS-ETS1-2: Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.	**VOCABULARY:** design, procedures, analysis, researching, brainstorming, developing, building, testing, reflection, criteria, constraints, mitigate, climate, impacts, atmosphere, phenomena, catastrophic, engineering, carbon dioxide, sustainability, engineering design process, ecosystem, methane, nitrous oxide, alternative energy (PV photo voltaic cell, solar, wind, geothermal, tidal and biofuel), trade-off **KEY TERMS:** upcycling, alternative technology, hardware, software, program, debug, redesign	

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MS-ETS1-3: Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success. MS-ETS1-4: Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved. **NJ 2020 SLS: Science – Crosscutting Concepts 6-8** • Cause and effect • Structure and function • Systems and system models **NJ 2020 SLS: Science – Science and Engineering Practices 6-8** • Asking questions and defining problems • Developing and using models • Planning and carrying out investigations • Analyzing and interpreting data • Using mathematics and computational thinking		

Unit III: Sustainable Solutions with Robotics

• Constructing explanations and designing solutions **NJ 2020 SLS: Science – Disciplinary Core Ideas 6-8** ETS1.A: Defining and Delimiting Engineering Problems ETS1.B: Developing Possible Solutions ETS1.C: Optimizing the Design Solution **NJ 2016 SLS: Literacy in History, Social Studies, & Technical Subjects** RST.6-8.7: Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table). **NJ 2016 SLS: Mathematical Practices** MP1: Make sense of problems and persevere in solving them. MP2: Reason abstractly and quantitatively. MP4: Model with mathematics. MP5: Use appropriate tools strategically. MP7: Look for and make use of structure.		

Unit III: Sustainable Solutions with Robotics

MP8: Looking for and expressing regularity in repeated reasoning.		

ASSESSMENT EVIDENCE: Students will show their learning by:

- Constructing, evaluating, and refining a robot to improve the efficiency of a process or address a real-world problem
- Reflecting in engineering design journal entries to properly identify criteria, constraints, modifications, and redesigns
- Engaging in weekly conference

KEY LEARNING EVENTS AND INSTRUCTION:

- Students will research and identify a sustainable technology or process that can be improved by robotics
- Students will build and code a robot to reduce the impact of a technology on the environment or society
- Students will test and refine their robot through the iterative design process and systematic troubleshooting based upon feedback

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Unit III: Sustainable Solutions with Robotics

SUGGESTED TIME ALLOTMENT	**4 Weeks**
SUPPLEMENTAL UNIT RESOURCES	Required Supplies/Activities/Software: Computers with Internet access Microsoft OneNote Lego Mindstorms Software Suggested Supplies/Activities/Software https://ev3lessons.com/en/ https://www.firstlegoleague.org/