Wayne
Township Public Schools

Technology Education
Grades 10 - 12
Robotics II
July 23, 2018
Robert Yost

Dr. Mark Toback, Superintendent

This curriculum may be modified through varying techniques, strategies, and materials as per an individual student's Individualized Educational Plan (IEP)

Wayne School District
Curriculum Format

Content Area/ Grade Level/ Course:	**Applied Technology** **10-12** **Robotics 2**
Unit Plan Title:	**Sensors, Communication, and Control**
Time Frame	**Twelve weeks**

Anchor Standards/Domain* *i.e: ELA: reading, writing i.e.: Math: Number and Operations in Base 10

8.2 Design Thinking This standard, previously standard 8.2 Technology Education of the 2014 NJSLS – Technology, outlines the technological design concepts and skills essential for technological and engineering literacy. The new framework design, detailed previously, includes Engineering Design, Ethics and Culture, and the Effects of Technology on the Natural world among the disciplinary concepts

9.2 Career Awareness, Exploration, Preparation and Training. This standard outlines the importance of being knowledgeable about one's interests and talents, and being well informed about postsecondary and career options, career planning, and career requirements.

Standard 9.4 Life Literacies and Key Skills. This standard outline key literacies and technical skills such as critical thinking, global and cultural awareness, and technology literacy* that are critical for students to develop to live and work in an interconnected global economy.

Anchor Companion Standards (Reading and Writing Grades 9-10)

Anchor Companion Standards (Reading and Writing Grades 11-12)

Unit Summary

- Unit Overview
  - Computing
  - Sensors
  - Communication
- Computing options
  - Microcontrollers
  - Single-board computers

        - Shields

- Sensor types
    - Proximity
    - Environmental
    - Proprioception

- Sensor Characteristics
    - Quality
    - Output
    - Energy requirements
    - Field of view

- Acquiring Data
    - Sensor calibration
    - Telemetry
    - Data logging

- Soldering
    - Equipment
    - Safety
    - Technique
    - Case studies

- Tethering
    - Wire characteristics
    - Interfacing
    - Cable harness

- Commercial Controllers
    - Survey
    - Dissection
    - Project interface

- Wireless Solutions
    - Infrared
    - Radio
    - Bluetooth
    - WiFi

- BYOD
    - Leveraging smartphones
    - Commercially available technologies
    - WYSIWYG design platforms

Standard Number(s)

8.2.5.ETW.1: Describe how resources such as material, energy, information, time, tools, people, and capital are used in products or systems.
8.2.5.ETW.2: Describe ways that various technologies are used to reduce improper use of resources.
8.2.5.ETW.3: Explain why human-designed systems, products, and environments need to be constantly monitored, maintained, and improved
8.2.12.ED.1: Use research to design and create a product or system that addresses a problem and make modifications based on input from potential consumers.
8.2.12.ED.2: Create scaled engineering drawings for a new product or system and make modifications to increase optimization based on feedback.
8.2.12.ITH.2: Propose an innovation to meet future demands supported by an analysis of the potential costs, benefits, trade-offs, and risks related to the use of the innovation.

Essential Question(s)

- How are robots utilized in the real world?
- How do robots sense their environment?
- How do robots communicate with others?
- Why do engineers collect sensor data from robots?
- How do robots process data?
- What are some solutions that we can utilize to send instructions to robots?
- Why do we use so many different wireless technologies?
- Can we use our BYOD solutions to communicate with our robots?
- Why do we need to review safety protocols?

Enduring Understandings

- Robots are often used to complete tasks that are dangerous, difficult, or repetitive.
- We can equip our robots with a variety of devices that will allow them to mimic human senses. (Or sense things that are beyond human capabilities!)
- Robots use small computers to process information in real time. This allows them to behave in autonomous or semi-autonomous fashion.
- We can use a variety of wired or wireless solutions to communicate with our robots.
- Engineers need to collect data from robots in real time. They also need to be able to log data so that they can study the performance of their robots in depth at a later date.
- There are trade-offs among compatibility, data transmission, and energy consumption that must be taken into account when choosing a wireless communication solution.
- Your BYOD solution is a potentially powerful instrument for robotic control and data collection.
- Safety for oneself and others should be the first priority of every designer.

In this unit plan, the following 21st Century themes and skills are addressed.

Check all that apply. 21st Century Themes		*Indicate whether these skills are **E**-Encouraged, **T**-Taught, or **A**-Assessed in this unit by marking **E, T, A** on the line before the appropriate skill.* 21st Century Skills	
X	**Global Awareness**	**E, T, A**	**Creativity and Innovation**
X	**Environmental Literacy**	**E, T, A**	**Critical Thinking and Problem Solving**
X	**Health Literacy**	**E, T, A**	**Communication**
X	**Civic Literacy**	**E, T, A**	**Collaboration**
X	**Financial, Economic, Business, and Entrepreneurial Literacy**		

Student Learning Targets/Objectives (Students will know/Students will understand)

Students will:

- Discuss how robotics are used in professional and academic practice
- Survey computing solutions frequently utilized in robotics.
- Compare sensor types frequently utilized in robotics.
- Use sensors to collect data.
- Use telemetry to acquire data.
- Control robots with tethered and wireless solutions.
- Use BYOD solutions for control or telemetry.
- Review lab safety procedures.
- Learn soldering fundamentals.

Assessments (Pre, Formative, Summative, Other) ***Denote required common assessments with an ****

- Pre-assessments
  - Diagnostic tasks
  - Anticipatory sets
- Formative assessments

- Group discussion
- Individual conference
- Verify understanding during guided activities
- Peer assessment
- Self assessment
- Reflection and goal-setting

- Summative assessments
  - Quizzes
  - Performance tasks

Teaching and Learning Activities	
Activities	Students explore and implement a variety of solutions to communicate with their robots. They augment their robots with sensors to collect data about their environment, use telemetry to display that information, and implement solutions that allow their robots to appropriately respond to changing conditions. They learn new techniques for controlling their robots and update their hardware, software, and electronics designs in response.

Differentiation Strategies	**Tiered performance tasks:**
	- Capstone:
	  - Students design a solution to augment a robot's capabilities or analyze its performance with sensors, telemetry, or wireless control. For example: Students use IR sensors or ultrasonics to mimic semi-autonomous behaviors found in contemporary automobiles.
	- Extension:
	  - Students extend their knowledge of engineering modeling and digital fabrication tools to design unique control and monitoring devices.
	- Accommodation:
	  - Students research BYOD control/telemetry solutions and share their findings with the class.

Resources

- Sketching materials
- BYOD resources
- CAD workstation/software

- Google Docs / Classroom
- Digital fabrication hardware/software/consumables
- Safety goggles and tools
- Hardware, actuators, chassis material, et cetera
- Projection system
- Student monitoring system
- Reference materials
- Sample robot

Content Area/ Grade Level/ Course:	**Applied Technology** **10-12** **Robotics 2**
Unit Plan Title:	**Manipulators**
Time Frame	**Twelve weeks**

Anchor Standards/Domain* *i.e: ELA: reading, writing i.e.: Math: Number and Operations in Base 10

8.2 Design Thinking This standard, previously standard 8.2 Technology Education of the 2014 NJSLS – Technology, outlines the technological design concepts and skills essential for technological and engineering literacy. The new framework design, detailed previously, includes Engineering Design, Ethics and Culture, and the Effects of Technology on the Natural world among the disciplinary concepts

9.2 Career Awareness, Exploration, Preparation and Training. This standard outlines the importance of being knowledgeable about one's interests and talents, and being well informed about postsecondary and career options, career planning, and career requirements.

Standard 9.4 Life Literacies and Key Skills. This standard outline key literacies and technical skills such as critical thinking, global and cultural awareness, and technology literacy* that are critical for students to develop to live and work in an interconnected global economy.

Anchor Companion Standards (Reading and Writing Grades 9-10)

Anchor Companion Standards (Reading and Writing Grades 11-12)

Unit Summary

- Course Overview
  - First year review and debriefing

        - Mechatronics approach
        - Policies and safety

- Unit Overview
    - Modeling review / assessment
    - Contextual modeling
    - Simulation
    - Arms / End-effectors

- Equations
    - Driving parameters
    - Variables
    - Composing and evaluating equations

- Assembly techniques
    - Advanced / mechanical mates
    - In-context modeling
    - Conceptual modeling

- Simulation
    - Interpolation
    - Force
    - Visualization

- Engineering modeling challenge
    - Problem solving process
    - Development
    - Presentation

- End-effectors
    - Sensors
    - Tools
    - Manipulators

- Arm Design
    - Workspace
    - Complexity
    - Actuators

- Actuator Survey
    - Stepper
    - Servo
    - Linear

- Design Challenge
    - Design process review
    - Goals / Constraints

- Documentation

Standard Number(s)

• 8.2.5.ETW.1: Describe how resources such as material, energy, information, time, tools, people, and capital are used in products or systems.
8.2.5.ETW.2: Describe ways that various technologies are used to reduce improper use of resources.
8.2.5.ETW.3: Explain why human-designed systems, products, and environments need to be constantly monitored, maintained, and improved
8.2.12.ED.1: Use research to design and create a product or system that addresses a problem and make modifications based on input from potential consumers.
8.2.12.ED.2: Create scaled engineering drawings for a new product or system and make modifications to increase optimization based on feedback.
8.2.12.ITH.2: Propose an innovation to meet future demands supported by an analysis of the potential costs, benefits, trade-offs, and risks related to the use of the innovation.

Essential Question(s)

- Find a recent article that discusses the development or use or robots for commercial, academic, or defense purposes.
- Can we define specific relationships between entities in a virtual model?
- What is the benefit of building a virtual prototype?
- What is design intent?
- Build a simple linkage.
- What is meant by 'design process'?
- What are the constraints that we must respond to when building a robotic arm?
- What kinds of actuators are most appropriate for animating arms and end effectors?
- How can we create physical replicas of the objects that we have modeled digitally?
- What are some safety procedures that we should adhere to when we use cutting or drilling tools?

Enduring Understandings

- Significant resources are being invested to develop robots that can complete dangerous, difficult, or repetitive tasks.
- We can enhance our productivity by defining relationships in a virtual model.
- Virtual prototypes can be made more rapidly and economically than physical prototypes.
- Digital models should be designed so they can be edited efficiently. They should respond to changes predictably.
- We can combine rigid links and joints to define a variety of movements.
- Designers typically employ a strategy to develop their ideas from concept to reality.
- Adhering to design constraints allows us to make products that are safe, functional, and desirable.

- We can select from a number of devices to animate a robotic arm.
- There are a variety of fabrication technologies that allow us to take advantage of different materials and modeling techniques.
- Safety for oneself and others should be the first priority of every designer.

In this unit plan, the following 21st Century themes and skills are addressed.

Check all that apply. 21st Century Themes		*Indicate whether these skills are **E**-Encouraged, **T**-Taught, or **A**-Assessed in this unit by marking **E, T, A** on the line before the appropriate skill.* 21st Century Skills	
X	**Global Awareness**	**E, T, A**	**Creativity and Innovation**
X	**Environmental Literacy**	**E, T, A**	**Critical Thinking and Problem Solving**
X	**Health Literacy**	**E, T, A**	**Communication**
	Civic Literacy	**E, T, A**	**Collaboration**
X	**Financial, Economic, Business, and Entrepreneurial Literacy**		

Student Learning Targets/Objectives (Students will know/Students will understand)

Students will:

- Discuss how robotics are used in professional and academic practice.
- Use equations to define parametric relationships.
- Build virtual assembly models.
- Simulate linkage mechanisms.
- Survey various end effectors.
- Consider constraints for robotic arm design.
- Compare actuators that are commonly used in robotic manipulation.
- Complete engineering design tasks.
- Use digital fabrication technology.
- Fabricate safely and appropriately.

Assessments (Pre, Formative, Summative, Other) ***Denote required common assessments with an ****	
- Pre-assessments - Diagnostic tasks - Anticipatory sets - Formative assessments - Group discussion - Individual conference - Verify understanding during guided activities - Peer assessment - Self assessment - Reflection and goal-setting - Summative assessments - Quizzes - Performance tasks	
Teaching and Learning Activities	
Activities	Students enrolled in the second year of the Robotics sequence continue to develop their knowledge of design, fabrication, electronics, and programming. They use engineering modeling software and digital fabrication tools to design and develop prototypes of robotics components. They take advantage of electronics and programming techniques to allow their robots to perceive their environment, communicate, and make decisions. As the year progresses, students engage in a series of mechatronics design challenges. Students advance their knowledge of engineering modeling software to build and simulate various linkage assemblies. They use this experience to conceptualize and develop virtual prototypes of robotic manipulators. They conduct simulations to confirm that their designs respond appropriately to a set of design constraints, and they utilize digital fabrication techniques to bring their ideas to life.
Differentiation Strategies	**Tiered performance tasks:** - Capstone: - Each student designs parts for a robotic manipulator, uses digital tools to fabricate their design, and assembles a final product.

	○ Extension: ▪ Students extend their knowledge of engineering modeling and digital fabrication tools. They use these resources to enhance the design of their manipulator. They continue to optimize the performance of their design after the conclusion of the assigned task. ○ Accommodation: ▪ Students work in project teams to model, fabricate, and test their manipulators. They may be paired with advanced students who assist them with assignments.

Resources

- Sketching materials
- BYOD resources
- CAD workstation/software
- Google Docs / Classroom
- Digital fabrication hardware/software/consumables
- Safety goggles and tools
- Hardware, actuators, frame material, et cetera
- Projection system
- Student monitoring system
- Reference materials
- Examples

Content Area/ Grade Level/ Course:	**Applied Technology** **10-12** **Robotics 2**
Unit Plan Title:	**Platform Design**
Time Frame	**Twelve weeks**
Anchor Standards/Domain*	***i.e: ELA: reading, writing i.e.: Math: Number and Operations in Base 10**

8.2 Design Thinking This standard, previously standard 8.2 Technology Education of the 2014 NJSLS – Technology, outlines the technological design concepts and skills essential for technological and engineering literacy. The new framework design, detailed previously, includes Engineering Design, Ethics and Culture, and the Effects of Technology on the Natural world among the disciplinary concepts

9.2 Career Awareness, Exploration, Preparation and Training. This standard outlines the importance of being knowledgeable about one's interests and talents, and being well informed about postsecondary and career options, career planning, and career requirements.

Standard 9.4 Life Literacies and Key Skills. This standard outline key literacies and technical skills such as critical thinking, global and cultural awareness, and technology literacy* that are critical for students to develop to live and work in an interconnected global economy.

Anchor Companion Standards (Reading and Writing Grades 9-10)

Anchor Companion Standards (Reading and Writing Grades 11-12)

Unit Summary

- Unit Overview
  - Fabrication
  - Powertrain
  - Design challenge

- Safety Review
  - Right to know
  - Shop tour
  - Hand tools
  - Digital fabrication

- 3D Printing
  - Modeling for efficiency
  - Speed, quality, adherence
  - Safety, operation, and maintenance

- Laser cutting
  - 3D to 2D conversion
  - Vector drawing technology
  - Machine safety and operation

- Frame
  - Materiality
  - Mounts
  - Hardware

- Approach to chassis design
  - Commercial solutions
  - Platform
  - Enclosure

- Case Study
  - Design process
  - Mock-up
  - Virtual prototype
  - Fabrication

- Existing Platforms
  - Military
  - Consumer
  - Commercial

- Power Supplies
  - Safety
  - Technologies
  - Rating
  - Estimation

- Actuator Survey
  - Brushed / Motor driver
  - Brushless / ESC
  - Continuous rotation servo

- Actuator Characteristics
  - Torque
  - Speed
  - Voltage
  - Current

- Gearing
  - Speed / torque
  - Gear anatomy
  - Types

- Drives
  - Holonomic
  - Non-holonomic
  - Walking

- Design Challenge
  - Design process review
  - Goals / Constraints
  - Documentation

Standard Number(s)

• 8.2.5.ETW.1: Describe how resources such as material, energy, information, time, tools, people, and capital are used in products or systems.
8.2.5.ETW.2: Describe ways that various technologies are used to reduce improper use of resources.
8.2.5.ETW.3: Explain why human-designed systems, products, and environments need to be constantly monitored, maintained, and improved
8.2.12.ED.1: Use research to design and create a product or system that addresses a problem and make modifications based on input from potential consumers.
8.2.12.ED.2: Create scaled engineering drawings for a new product or system and make modifications to increase optimization based on feedback.
8.2.12.ITH.2: Propose an innovation to meet future demands supported by an analysis of the potential costs, benefits, trade-offs, and risks related to the use of the innovation.

Essential Question(s)

- What are some safety procedures that we should adhere to when we use cutting or drilling tools?
- Discuss best practices for 3D printing.
- How do we prepare our models to be laser cut?
- What are some fundamental constraints that we have to consider when we design the frame of a robot?
- What are some approaches to chassis design?
- What is meant by 'design process'?
- Find a recent news article that discusses a consumer, military, or commercial robot.
- What is a transmission?
- What is an actuator?
- Why should I maintain a portfolio?

Enduring Understandings

- Safety for oneself and others should be the first priority of every designer.
- We can improve the quality of our parts by carefully considering how they are fabricated.
- Vector drawing tools are often used to define paths for a laser cutter.
- Cost, strength, weight, and machinability are fundamental considerations when specifying frame components and materials.
- Robotic chassis are typically open or enclosed. Each approach offers advantages.
- Designers typically employ a strategy to develop their ideas from concept to reality.

- Robots can be used to improve our quality of life.
- Transmissions use gear reduction to increase torque while reducing speed.
- Actuators convert electric power into mechanical motion.
- You need to be able to demonstrate your capabilities and growth to others and yourself.

In this unit plan, the following 21st Century themes and skills are addressed.

Check all that apply. 21st Century Themes		*Indicate whether these skills are **E**-Encouraged, **T**-Taught, or **A**-Assessed in this unit by marking **E, T, A** on the line before the appropriate skill.* 21st Century Skills	
X	**Global Awareness**	**E, T, A**	**Creativity and Innovation**
X	**Environmental Literacy**	**E, T, A**	**Critical Thinking and Problem Solving**
X	**Health Literacy**	**E, T, A**	**Communication**
	Civic Literacy	**E, T, A**	**Collaboration**
X	**Financial, Economic, Business, and Entrepreneurial Literacy**		

Student Learning Targets/Objectives (Students will know/Students will understand)

Students will:

- Discuss how robotics are used in professional and academic practice
- Learn best practices for digital fabrication.
- Consider design constraints for frame and chassis design.
- Utilize a design / problem-solving process.
- Consider the effect of various design parameters on cost and quality.
- Complete engineering design tasks.
- Discuss current events in robotics/mechatronics.
- Survey a variety of actuators.
- Survey a variety of robotic drives.
- Understand the importance of a transmission.
- Create and maintain a portfolio

Assessments (Pre, Formative, Summative, Other)	***Denote required common assessments with an ****

- Pre-assessments
  - Diagnostic tasks
  - Anticipatory sets
- Formative assessments
  - Group discussion
  - Individual conference
  - Verify understanding during guided activities
  - Peer assessment
  - Self assessment
  - Reflection and goal-setting
- Summative assessments
  - Quizzes
  - Performance tasks

Teaching and Learning Activities	
Activities	During this unit, students continue to develop their repertoire of prototyping techniques. They assume the responsibility for designing and fabricating a robotic platform. They analyze constraints, consider the equipment at their disposal, conceptualize potential solutions, and generate a virtual prototype. After peer and teacher review, they finalize their designs and fabricate a physical prototype.
Differentiation Strategies	**Tiered performance tasks:** o Capstone: ▪ Each student designs parts for a robot, uses digital tools to fabricate them, and assembles a final product. They document their process in a portfolio. o Extension: ▪ Students extend their knowledge of engineering modeling and digital fabrication tools. They use these resources to enhance the design of their robot or conceptualize a new one. They continue to optimize the performance of their robot after the conclusion of the assigned task.

	○ Accommodation: ▪ Students work in project teams to model, fabricate, and test their robots. They may be paired with advanced students who assist them with assignments.

Resources

- Sketching materials
- BYOD resources
- CAD workstation/software
- Google Docs / Classroom
- Digital fabrication hardware/software/consumables
- Safety goggles and tools
- Hardware, actuators, chassis material, et cetera
- Projection system
- Student monitoring system
- Reference materials
- Sample robot

Content Area/ Grade Level/ Course:	**Robotics 2**
Unit Plan Title:	**NJIT Digital Fabrication**
Time Frame	
Anchor Standards/Domain* **Operations in Base 10**	***i.e: ELA: reading, writing i.e.: Math: Number and**

ELA-Literacy: Science and Technical Subjects

SOCIAL STUDIES: Economics, Innovation, and Technology

HS-ETS: Engineering

MATH: HSN: Number and Quantity

MATH: Modeling

MATH: HSG: Geometry

MATH: HSS: Statistics and Probability

8.2 Technology Education, Engineering, Design and Computational Thinking - Programming: D. Abilities for a Technological World

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

9.3 CAREER AND TECHNICAL EDUCATION: MANUFACTURING CAREER CLUSTER

9.3 CAREER AND TECHNICAL EDUCATION: SCIENCE, TECHNOLOGY, ENGINEERING & MATHEMATICS CAREER CLUSTER

Unit Summary

Course Introduction
- NJIT syllabus
- Mechatronics
- Safety guidelines

Mechatronics survey
- Mechanics / CAD
- Electronics / Schematics
- Software development / Fritzing

CAD fundamentals
- System overview
- Sketching
- Modeling