Robotics & Automation

Levels: Grades 10-12
Units of Credit: 1.0
CIP Code: 21.0117
Core Code: 38-01-00-00-130
Prerequisite: None
Skill Test: 612

COURSE DESCRIPTION
Robotics & Automation is a lab-based, hands-on curriculum combining electrical, mechanical and engineering principles. Students will learn to design, build, program and control robotic devices by applying science, technology, engineering and math concepts. A rigorous study and application of electrical concepts will include: sources of energy, electrical safety, use and identification of basic electronic components, sensors and actuators. Engineering concepts will include: mechanical design, prototype development, design testing, programming, and proper engineer documentation. Industrial automation, robotic applications and career opportunities will also be discussed.

Course Orientation
The Robotics and Automation course is part of the Engineering Pathway and intended to be a STEM course (Science, Technology, Engineering and Math). This is not a “hobby” class. Students need to see the application of science concepts and use math. Technology is more than the use of computers and other digital gadgets. Technology is a body of knowledge which should be studied. Basic concepts of engineering-design & problem solving should be infused throughout the curriculum. This course should help students become more technologically literate and appreciate how robotics and automation affects our lives.

Length of Course: A full year curriculum is strongly recommended to allow enough time for hands-on applications, experimentation, engineering, robot development, and competitive events. This could be accomplished by offering one year-long course, or two semester courses. The two semester option would require a first semester prerequisite to enroll in the advanced class. The two semester option would allow for greater flexibility in school scheduling.

CORE STANDARDS, OBJECTIVES, AND INDICATORS

STANDARD 1
Students will identify the history and application of technology and engineering as it applies to robotics and automated systems.

Objective 1: Students will identify the definition and historical impact of technology.
Sample definitions:
- Technology is the practical application of knowledge and resources to solve problems and provide for our needs and wants.
- Technologies are the processes and products that people have developed to solve problems, extend human ability, or satisfy human needs.

a. Contrast the positive and negative social, economic, and environmental impacts of a technological process, product, or system.
b. Explain the influence of technology on history and the shaping of contemporary issues.

**Objective 2:** Students will identify the definition and historical impact of **engineering** within global, economic, environmental, and societal needs.

Sample definitions:
- Engineering is the use of math, science, and technology to create useful products and systems or improve those that already exist.
- An Engineer is one who transforms knowledge of mathematics and sciences into practical applications through the engineering design and problem solving process.

a. Define engineering as it applies to the robotic and automation industry.
b. Identify 4 engineering fields that impact the robotic and automation industry.

**Objective 3:** Students will identify the definition and historical impact of **robotic and automated systems** and their benefit to society.

a. Define a robot.
   Sample definition:
   - A robot is any device that emulates human movement, capabilities, or appearance; from the Czech word “robata”.
   - A robot is an automatically controlled, reprogrammable, multipurpose machine.
b. Define automated manufacturing/systems.
c. Describe the history and early beginnings of automated manufacturing & robotics.
d. Explain how automation and robotic systems have improved the quality of life, increased production, precision, and safety a variety of applications.

**STANDARD 2**

**Students will follow safety practices.**

**Objective 1:** Follow **general laboratory safety** practices.

a. Assess workplace conditions with regard to safety and health.
b. Align safety issues with appropriate safety standards to ensure a safe workplace/jobsite.

**Objective 2:** Follow specific **equipment safety** practices.

a. Use personal protective equipment according to manufacturer rules and regulations.

**Objective 3:** Identify **potential safety hazards**.

a. Identify safety precautions to maintain a safe worksite.
b. Select appropriate personal protective equipment as needed for a safe workplace/jobsite.

**STANDARD 3**

The student will understand, apply and document the Engineering Design Process.

(Typical Engineering Design models include: 1) A **Conceptual Stage** which defines the problem and brainstorms ideas. 2) A **Developmental Stage** where ideas are explored, research done, and a prototype built. 3) An **Evaluation Stage** where the idea is tested, refined, and a final report is made. Adopt an engineering design model that includes these elements.)

**Objective 1:** Students will demonstrate the ability to clearly formulate a **problem statement**.

a. Identify that a problem exists.
b. State or write the problem clearly.

**Objective 2:** Students will demonstrate the ability to identify and analyze design **constraints**.
a. Analyze typical constraints: time, energy, space or area, tools, people, materials, capital and information.
b. Document constraints that have a positive or negative effect on the design problem.

Objective 3: Students will demonstrate the ability to investigate and research information pertaining to the design brief and choose the best solution
a. Brainstorm and research information that is currently available.
b. Identify conditions or factors which may affect the solution such as appearance, durability, simplicity and safety.
c. Use sketches and notes in the process of generating alternative design solutions.
d. Select the best solution or design using a decision matrix.

Objective 4: Students will develop a detailed working drawing for their solution.
a. Students will be familiar with CAD software and/or hand drawing.
b. Understand and use the alphabet of lines, orthographic views and dimensioning.
c. Created a detailed drawing.
d. Generate a parts list.

Objective 5: Students will implement the design by building a model or prototype.
a. Create a chart that shows the build schedule and the team work assignments.
b. Students will use their parts list to obtain needed material.
c. Using safety procedures construct the prototype.
d. Students will demonstrate the use of simple machines and show how they are used in structural design of complex devices and machines.

Objective 6: Students will demonstrate the ability to test, analyze and optimize their design
a. Test the prototype, apply math calculations, and document the results.
b. Re-design and improve the prototype.

Objective 7: Students will demonstrate the ability to document, evaluate, and report on the final design.
a. Summarize the design process use in the product development.
b. Defend the final prototype.
c. Make a formal presentation to the class.

STANDARD 4
Students will be able to identify, understand, and utilize mechanical advantage and power efficiency to perform robotic tasks. These tasks will include concepts of force, torque, mechanical rates and friction.

Objective 1: Students will identify the six simple machines and apply their use to a structural design. The six simple machines defined by Renaissance scientists are:
a. Levers
b. Wheel and axle
c. Pulley
d. Inclined plane
e. Wedge
f. Screw
Objective 2: Student will analyze the effects of various forces on a mechanical device. (Every force is a vector and has two components, magnitude and direction.)

   a. Discuss and demonstrate the following forces in English and Metric units:
   - Gravitational forces
   - Friction or drag forces
   - Normal force
   - Horizontal and vertical forces
   - Rotational forces called torque

Objective 3: Calculate and demonstrate mechanical advantage of gears, pulleys, and levers.

Objective 4: Calculate and measure mechanical rates, including linear velocity, linear acceleration, angular speed, and angular acceleration.

   a. Discuss the difference between speed, velocity and acceleration
   b. Calculate and measure linear velocity in both English and Metric units
   c. Calculate and measure angular speed in English and metric units
   d. Calculate and measure linear and angular acceleration in both English and Metric units

Objective 5: Describe the effects of friction.

   a. Discuss the advantages and disadvantages of friction.
   b. Calculate friction applying the coefficient of friction and normal force
   c. Demonstrate rolling friction and explain why it reduces friction

Objective 6: Describe power and efficiency.

   a. Calculate mechanical power:
   - Horse power
   - Watts
   b. Define and calculate power efficiency
   c. Apply and calculate power efficiency by using an electric motor, pneumatics, or hydraulics to lift a payload.

STANDARD 5
The student will identify sources of energy and process of energy conversion.

Objective 1: Compare and contrast energy sources and their ability to change to other forms of energy.

   a. Describe and contrast energy sources.
   b. Identify and contrast sources of electrical energy including AC and DC.
   c. Describe energy ratings such as amp/hour and kilowatt/hour.

Objective 2: Explain how energy in a robotic system is converted and used (chemical, electrical, magnetic, mechanical, heat, etc.).

Objective 3: Use a batteries, solar cells or generator to provide energy for the operation of small motors and other mechanical devices.

   a. Identify batteries and describe their uses and hazards.
b. Properly connect and disconnect batteries and power supplies.
c. Define and calculate increase performance through series and parallel connections.

STANDARD 6
Students will understand the fundamentals of analog and digital electronics as they apply to robotics.

Objective 1: Students will calculate voltage, amperage, and resistance using Ohms Law.

Objective 2: Students will use a multi-meter to measure voltage, amperage, and resistance.

Objective 3: Students will define series, parallel, and series/parallel circuits.

Objective 4: Students will apply binary devices which operate in on or off states.

Objective 5: Apply digital logic to a problem solving situation.
   Examples:
   • Following a line.
   • Avoiding an obstacle.
   • Turning on an alarm.

STANDARD 7
Students will identify the elements of a technological system.

Objective 1: Students will create a device control flow chart.
   a. Students will identify the input, process, output, and feedback of a system.

Objective 2: Students will define a Closed-Loop and Open-Loop systems.

STANDARD 8
Students will define and apply various electrical control devices to a robotic system.

Objective 1: Students will apply sensors to obtain feedback.

Objective 2: Students will apply switches and sensors to control robot movement.

STANDARD 9
Students will be able to create, and interpret fundamental programming of robots and automated systems.

Objective 1: Students will be able to identify and explain control flow statements (loop, if, then, else, etc.) and how they are used in a program to operate a robot.

Objective 2: Students will be able to create an algorithm and flow chart to write a program.
Objective 3: Students will be able to interpret and identify the **difference between logic and syntax**.

Objective 4: Students will be able to compile and utilize a personal **library of commands**.

Objective 5: Students will be able to identify and **use variables in programming**.

Objective 6: Students will be able to **create and explain a program that utilizes input and output commands**.

**STANDARD 10**

Students will compare and contrast various mechanical systems, and the industrial application of robotic and automation.

Objective 1: Describe the advantages and disadvantages for each of the following industrial **robotic systems**:
- Stepper motors
- Hydraulics
- Pneumatics

Objective 2: Identify the **uses of robotics** in industry and how it impacts manufacturing and production.
   a. Identify the advantages and disadvantages of automated assembly lines.
   b. Describe how robotics can improve manufacturing safety.
   c. Identify five or more industries that utilize robotic applications.

**STANDARD 11**

Students will identify the ethical and social impacts of robotics and automation.

Objective 1: Contrast the **social benefits** and the negative **consequences** of robotics and automation.

Objective 2: Describe the **ethical impact** of robotics and automation.
   Example discussion points:
   - Discuss military and political use of robots; e.g. spy bugs and drones.
   - Discuss who is responsible for a robot’s intended use; e.g. a robot made to search a mine v/s the same technology used to invade someone’s privacy.
   - Discuss ethical and professional behavior in the development and use of technology.

Objective 3: Students will explain the application of **copyright and patent laws**.

**STANDARD 12**

Students will be able to identify and report on educational pathways and career opportunities in robotics and automation.
## Proposed Instructional Timeline and Standard Priority
(Base on a full-year course, 180 days, 45 minute class-period.)

<table>
<thead>
<tr>
<th>Std.</th>
<th>Description</th>
<th>% of course</th>
<th>Suggested days (including instruction and activities)</th>
<th>8 period schedule</th>
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<tr>
<td>1</td>
<td>History and application of technology, engineering, robotics and automation.</td>
<td>4</td>
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<td>2</td>
<td>Industrial and student safety</td>
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<td>5</td>
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<td>3</td>
<td>Understanding and applying the Engineering Design Process</td>
<td>18</td>
<td>32</td>
<td>16</td>
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<tr>
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<td>Simple machines and mechanical advantage</td>
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<td>13</td>
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<td>Sources of energy and energy conversion</td>
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<td>8</td>
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<td>6</td>
<td>Analog and digital electronics</td>
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<td>30</td>
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<td>Electrical control systems and devices</td>
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<td>Mechanical systems and industrial application</td>
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<td>Educational pathways and career opportunities</td>
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*Total days have been discounted by 5% for conflicts in scheduling and school activities.