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| **Lesson 1.2 Control Systems - Roemer** |

**Preface**

The word *sabotage* comes from the root word *sabot*, a type of wooden shoe. The legend goes that during labor disputes, workers threw their shoes into the machinery, causing it to jam. Would this be possible in a factory today? How can you create a system that will detect a problem and stop the machinery before it is damaged?

In this lesson students will learn how to create a control system. Students will first look at flowcharts; they will learn the symbols and applications that can be associated with them. Students will apply this knowledge to create simple automated devices which will lead to the design of a product transfer system.

**Concepts**

1.    Flowcharting is a powerful graphical organizer used by technicians, computer programmers, engineers, and professionals in a variety of roles and responsibilities.

2.    During the design and development process, flowcharting is used to plan and depict the process flow for an entire system and all of its subsystems.

3.    Computer programmers use flowcharting symbols to graphically organize the flow of program control, including all inputs, outputs, and conditions that may occur.

4.    Everyday products including cars, microwaves, ovens, hair dryers, coffee pots, and washing machines all use control systems to manage their operation.

**Standards and Benchmarks Addressed**

***Standards for Technological Literacy***

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| **Standard 1:** | Students will develop an understanding of the characteristics and scope of technology. |
| **BM J:** | The nature and development of technological knowledge and processes are functions of the setting. |
| **Standard 2:** | Students will develop an understanding of the core concepts of technology. |
| **BM W:** | Systems’ thinking applies logic and creativity with appropriate compromises in complex real-life problems.  |
| **BM Y:** | The stability of a technological system is influenced by all of the components in the system, especially those in the feedback loop. |

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| **BM AA:** | Requirements involve the identification of the criteria and constraints of a product or system and the determination of how they affect the final design and development. |
| **BM FF:** | Complex systems have many layers of controls and feedback loops to provide information. |
| **Standard 8:** | Students will develop an understanding of the attributes of design. |
| **BM J:** | The design needs to be continually checked and critiqued, and the ideas of the design must be redefined and improved. |
| **Standard 9:** | Students will develop an understanding of engineering design. |
| **BM J:** | Engineering design is influenced by personal characteristics, such as creativity, resourcefulness, and the ability to visualize and think abstractly. |
| **BM K:** | A prototype is a working model used to test a design concept by making actual observations and necessary adjustments. |
| **BM L:** | The process of engineering design takes into account a number of factors. |
| **Standard 10:**  | Students will develop an understanding of the role oftroubleshooting, research and development, invention and innovation, and experimentation in problem solving. |
| **BM L:** | Many technological problems require a multidisciplinary approach. |
| **Standard 11:** | Students will develop abilities to apply the design process. |
| **BM R:** | Evaluate final solutions and communicate observation, processes, and results of the entire design process, using verbal, graphic, quantitative, virtual, and written means, in addition to three-dimensional models. |
| **Standard 12:** | Students will develop the abilities to use and maintain technological products and systems. |
| **BM L:** | Document processes and procedures and communicate them to different audiences using appropriate oral and written techniques. |
| **BM M:** | Diagnose a system that is malfunctioning and use tools, materials, machines, and knowledge to repair it.  |
| **BM N:** | Troubleshoot, analyze, and maintain systems to ensure safe and proper function and precision. |
| **BM O:** | Operate systems so that they function in the way they were designed. |
| **Standard 13:** | Students will develop the abilities to assess the impact of products and systems. |
| **BM J:** | Collect information and evaluate its quality. |
| **Standard 16:** | Students will develop an understanding of and be able to select and use energy and power technologies. |
| **BM N:** | Power systems must have a source of energy, a process, and loads. |
| **Standard 17:** | Students will develop an understanding of and be able to select and use information and communication technologies. |
| **BM M:** | Information and communication systems allow information to be transferred from human to human, human to machine, machine to human, and machine to machine. |
| **BM O:** | Communication systems are made up of source, encoder, transmitter, receiver, decoder, storage retrieval and destination. |
| **BM Q:** | Technological knowledge and processes are communicated using symbols, measurement, conventions, icons, graphic images, and languages that incorporate a variety of visual, auditory, and tactile stimuli. |
| **Standard 19:** | Students will develop an understanding of and be able to select and use manufacturing technologies. |
| **BM P:** | The interchangeability of parts increases the effectiveness of manufacturing processes. |

***National Science Education Standards***

**Unifying Concepts and Processes:**  As a result of activities in grades K-12, all students should develop understanding and abilities aligned with the following concepts and processes.

         **Systems, order, and organization**

         **Evidence, models, and explanation**

**Science and Technology Standard E:** As a result of activities in grades 9-12, all students should develop

         **Abilities of technological design**

         **Understandings about science and technology**

***Standards for English Language Arts***

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| **Standard 4:** | Students adjust their use of spoken, written, and visual language (e.g., conventions, style, vocabulary) to communicate effectively with a variety of audiences and for different purposes. |
| **Standard 5:** | Students employ a wide range of strategies as they write and use different writing process elements appropriately to communicate with different audiences and for a variety of purposes. |
| **Standard 12:** | Students use spoken, written and visual language to accomplish their own purposes (e.g. for learning, enjoyment, persuasion, and the exchange of information). |

**Performance Objectives**

*It is expected that students will:*

    Identify basic flowcharting symbols and discuss their functions.

    Create a flowchart that portrays a manufacturing process.

    Apply flowcharting to areas other than manufacturing.

    Identify a control system and explain its application to manufacturing.

    Model and create a program to control an automated system.

**Assessment**

*Explanation*

1.    Students will explain the function of a flowchart.

2.    Students will discuss other areas in which flowcharting methods can be applied (e.g., business, health, education, etc.).

*Application*

3.    Using five or more steps, students will develop a flowchart to describe a manufacturing process.

4.    Using five or more steps, students will develop a flowchart to describe a computer program process.

5.    Students will apply flowcharting skills to create control systems.

**Essential Questions**

1.    What are the benefits of using flowcharting in manufacturing?

2.    During which stage(s) of the design process is flowcharting used?

3.    Outside of design, in what other areas can flowcharting methods be applied?

4.    How can a control system be designed to make a transfer system function?

5.    What is the difference between open and closed loop systems?

6.    How is it possible to instruct a machine to interact with its surroundings and call attention if something goes wrong?

**Key Terms**

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| **Automation** | The use of technology to ease human labor or extend the mental or physical capabilities of humans.  |
| **Closed Loop** | A system that uses feedback from the output to control the input. |
| **Control System** | A system in which one or more outputs are forced to change in a desired manner as time progresses.  |
| **Decision Block** | The diamond-shaped block used for YES/NO questions. These blocks have two outputs, 1 (for yes) and 2 (for no). |
| **Flow Chart** | A graphical representation of the progress of a system for the definition, analysis, or solution of a data-processing or manufacturing problem. |
| **Flow Lines** | The connecting line or arrow between symbols on a flow chart. |
| **Input/Output Block** | A function that makes information available for processing or records processed information. |
| **Interface** | The connection between the computer and the control system. |
| **Iterative** | Process flow that may repeat or skip steps until some condition is satisfied. |
| **Open Loop** | A control system that has no means for comparing the output with input for control purposes. An open-loop system often requires human intervention. |
| **Potentiometer** | A variable resistor. |
| **Process Block** | Part of a flowchart that tells the program what action to take. |
| **Schematic** | A diagram that uses special symbols in place of actual pictures. In a wiring schematic, for example, a squiggly line is used to represent a resistor. |
| **Sequential** | Occurring in regular succession without gaps. |
| **Simulation** | A representation of a situation or problem with a similar but simpler model or a more easily manipulated model in order to determine experimental results. |

**Day-by-Day Plans**

*Time: 5 days*

**Day 1:**

    The teacher will present **Concepts**, **Key Terms**, and **Essential Questions** in order to provide a lesson overview.

    The teacher will present **Control Systems.ppt**.

    Students will take notes in their journals.

    The teacher will present **Flowcharting.ppt**.

    Students will begin work on **Activity 1.2.1 Flowcharting**.

    **Note:** The teacher wuill distribute **Activity 1.2.1a Flow Chart Tutorial** if students are struggling with the creation and understanding of this concept.

**Day 2-4:**

* The teacher will introduce and explain expectations for **Project 1.2.3 Freight Elevator** and the **Project Report Template**.
* Students will work in teams of two to three to document progress in their engineer’s notebooks.
* Students will complete work on **Project 1.2.3 Freight Elevator**and submit their engineer’s notebooks and a report using the **Project Report Template**.

**Day 5:**

         The teacher will distribute **Lesson 1.2 Fischertechnik® Programming Assessment**.

         Students will complete **Lesson 1.2 Fischertechnik® Programming Assessment**.

**Instructional Resources**

Presentations

**Control Systems**

**Flowcharting**

**RoboPro Introduction**

Word Documents

**Activity 1.2.1 Flowcharting**

**Activity 1.2.2a Introduction to the Interface**

**Activity 1.2.2b Diagnostic Lab**

**Activity 1.2.2c Basic Programming**

**Activity 1.2.2d Branches**

**Activity 1.2.2e Variables**

**Activity 1.2.2f Open Loop Control**

**Activity 1.2.2g Closed Loop Control**

**Activity 1.2.2h Potentiometers**

**Activity 1.2.2i Photo Sensors**

**Activity 1.2.2j Subprogram**

**Project 1.2.3 Freight Elevator**

**Lesson 1.2 Fischertechnik® Programming Assessment**