SCIENCE NORTH SCIENCE NORD
SUDBURY, ONTARIO, CANADA

Programmable Hydraulic Systems SPH4C

Lesson Plan

Coding Tool	Arduino
Cross-curricular	See extension section

Big Ideas

- Demonstrate an understanding of the scientific principles related to fluid statics, fluid dynamics, and hydraulic and pneumatic systems.
- Investigate real and simulated mixed direct current circuits
- Investigate energy transformations and the law of conservation of energy, and solve related problems

Specific Expectations

- Conduct a laboratory inquiry or computer simulation to demonstrate Pascal's principle
- Construct a simple device that makes use of energy transformations (e.g., a pendulum, a roller coaster), and use it to investigate transformations between gravitational potential energy and kinetic energy
- Construct real and simulated mixed direct current (DC) circuits (i.e., parallel, series, and mixed circuits), and analyse them in quantitative terms to test Kirchhoff's laws

Description

This lesson will take place over the course of approximately 5 days and could be used as a culminating activity for the course as it does encompass all strands of the SPH4C course. It's main ties to the course will be in the Hydraulics and Pneumatics system unit and the lesson is designed with the thought that this project would be completed at the end of the course.

For this lesson students will build a hydraulic system using syringes filled with water to demonstrate Pascal's principle. This system will be controlled using an Arduino, bread board, and DC motor. Students will need to also be familiar with simple circuits, electrical terms, and components when completing this activity. The code needed for this project is quite simple. I recommend taking one class to familiarize students with the basics of the code and how the Arduino works by having them configure a simple circuit and play with some code to make some LEDs change and blink. Once familiar with the code basics, the code to control the DC motor and make it go forward and backwards, along with a circuit diagram, may be provided to the students depending on what the goals for the students may be.

Materials

The material written here is per each group:

- 1 Arduino Uno beginners kit with bread board and electrical components including:
- 1 DC motor
- wires
- resistors
- transistors and/or H-Bridge
- potentiometer (Speed control)
- 1 9v battery with connectors to breadboard
- 1 breadboard
- 2 or more buttons

You can purchase most beginner kits that will include all of the above components

Computational Thinking Skills

- Algorithm design during the development of the code
- Decomposition while writing the code but also why breaking the system down into its many components and parts and finding ways for them to work together

Introduction

As an introduction to using the Arduino Unos and attached circuits students will construct small circuits involving LEDs. They can start by having them blink when the code is run, they can lead up to having different patters of LEDs including creating an "Intersection with stoplights" using groups of 1 red, 1 green, and 1 yellow LED. These activities help to introduce how to approach problems in a programmatic manner by breaking the problem down into a series of ordered steps.

Students should also complete a circuit where a button or switch on the circuit board will turn lights on and off as long as the code is running to familiar themselves with the type of event-driven programming that will be used to operate many of their hydraulic systems

Action

The bulk of this lesson will be the students in groups brainstorming ideas for their system and constructing the system using materials either provided by the teacher or brought in themselves. Many of these systems can be constructed using popsicle sticks, hot glue guns, pegs or dowels, and/or copper wire.

As I mentioned above the code require to make a DC motor run in both directions as well as the code to have the DC motor be able to change speeds are both included and can be provided to students or the students can write the code themselves if able. The electrical circuits needed to control a DC motor with an Arduino are also provided and again can be given to students on they can be asked to construct it themselves depending on what skills are being evaluated.

Consolidation/Extension

For this portion it really depends on how this lesson is being evaluated. If this is being used as a culminating activity, then it would be a good idea to have the students completely construct the circuit on their own with the aide of any schematics. Also have them include the circuit diagram.

Students can also measure certain aspects of the movement of their hydraulic system, for example a hydraulic lift, in order to discuss the forces acting on the lift as well as the acceleration.

There is an excellent opportunity for cross curricular learning with this project as the system they create can be designed to do just about anything. Some examples could be a model hydraulic lift similar to those seen in a mechanic shop, many of these students may be interested in this and also taking a shop or mechanics class. There are also hydraulic systems used in theatrical presentations to move stage parts, in bakeries and food plants to move products down an assembly line. Hydraulic systems are everywhere in our daily lives so this is a good opportunity for students to learn where they may find these systems in a career they are interested in.

Assessment

See Attached Rubric

Additional Resources

Along with many Arduino starter kits there is a book on beginner projects outlining the circuits and code necessary. Having one of these books is very useful for students and teachers to reference:
https://bastiaanvanhengel.files.wordpress.com/2016/06/arduino_projects_book.pdf