SCIENCE NORTH SCIENCE NORD
SUDBURY, ONTARIO, CANADA

Hydraulics and Pneumatics **Grade 12 – Hydraulics and Pneumatics**

Lesson Plan

Assessment	AFL, AOL
Cross-curricular	

Big Ideas

- Fluids under pressure can be used to do work.
- Fluids under pressure have predictable properties and many technological applications.
- The uses of hydraulic and pneumatic systems can have social and economic consequences.

Learning Goals

- I can give reasons for using hydraulic or pneumatic systems for mechanical tasks.
- I understand that a small force acting over a small surface area can produce a larger force acting over a larger surface area creating a mechanical advantage.
- I can design and construct a hydraulic system.

Specific Expectations:

F1. analyse the development of technological applications related to hydraulic and pneumatic systems, and assess some of the social and environmental effects of these systems;

F1.2 analyse some of the social and economic consequences of the use of robotic systems for different kinds of operations (e.g., in the manufacturing of computers, for lifting and maneuvering heavy objects on assembly lines, for handling hazardous materials, for activities under water and in space) [AI, C]

F2. investigate fluid statics, fluid dynamics, and simple hydraulic and pneumatic systems;

F2.4 conduct a laboratory inquiry or computer simulation to demonstrate Pascal's principle [PR]

F2.7 design and construct a hydraulic or pneumatic system (e.g., a braking system for a car, a clamping device, a model of a crane), solving problems as they arise, and evaluate the system with respect to mechanical advantage and efficiency [IP, PR, AI]

F3. demonstrate an understanding of the scientific principles related to fluid statics, fluid dynamics, and hydraulic and pneumatic systems.

F3.2 state Pascal's Principle, and explain its applications in the transmission of forces in fluid systems

F3.3 describe common components used in hydraulic and pneumatic systems (e.g., cylinders, valves, motors, fluids, hoses, connectors, pumps, reservoirs), and explain their function

Description:

In this lesson students will use syringes filled with liquid and gas to investigate Pascale's Principle. They will also design and construct a hydraulic system. This lesson may take 2-3 periods (75 minutes each) and should take place after students have learned how to do calculations using Pascal's Principle. **This lesson is intended for the college level.**

Materials

Fluid Systems visuals
Fluids Systems Venn Diagrams (Student and Teacher)
Investigating Hydraulics (Student)

Pascal's Principle Activity (Investigation Hydraulics) Group Materials

- 2 10 cc syringes
- 1 20 cc syringe
- 1 60 cc syringe
- Plastic tubing
- Water
- Ruler

Hydraulic Arm Challenge

Group Materials

Plastic syringes (10 cc, 20 cc, 60 cc), Plastic tubing (wait to get the syringes to see what will fit), Wood Scraps, Cardboard, Bolts, Screws, Nuts, Washers, Nails, zip ties, fasteners, Other approved items, Drill (for teacher use or under supervision of the teacher),

Hydraulic Arm Challenge…

Saw (for teacher use) and Safety glasses
Hydraulic Arm Challenge
Hydraulic Arm Rubric
Fluids System Assignment
Fluids System Assignment Rubric

Safety Notes

Students are to be supervised when using power tools and teacher should be the only one using the saw during the Robot Arm Activity. Students are wear safety glasses during the Robot Arm Activity.

Introduction

During the first class period, students should use the Fluid Systems visuals (See Link) to learn about hydraulic and pneumatic systems. Students complete a Fluids Systems Venn Diagram (See Link) during the presentation.

Hydraulic and pneumatic systems are used in many machines and robots to perform useful tasks by transmitting force from one point to another through a fluid. These systems can produce a mechanical advantage due to ***Pascal's Principle***; pressure applied to a fluid is transmitted equally to all parts of the fluid and container. This principle is what allows a small force applied to a small area to produce a larger force over a larger surface area.

$$\frac{F_{small}}{A_{small}} = \frac{F_{large}}{A_{large}}$$

This produces a mechanical advantage of

$$mechanical\ advantage = \frac{F_{output}}{F_{input}} = \frac{F_{large}}{F_{small}}$$

Action

Next, in pairs, students investigate Pascal's principle and start to think of how to use plastic syringes and tubing to control components. They may also begin to design their hydraulic arm. The design, construction, and testing of the hydraulic arm may take up to two class periods.

Group Materials
2 10 cc syringes
1 20 cc syringe
1 60 cc syringe
Plastic tubing
Water
Ruler

Instructions
Hydraulic systems have been used in prosthetics since 2008 to help create more realistic and sensitive movements. Now that you understand how to use "master" cylinders of different diameters to control "slaves", you may begin to build a robot arm.

Hydraulic Arm Challenge
With your group of 3-4, you will build an arm that uses a hydraulic system to move an empty pop can over a 20 cm x 20 cm "wall" and set it down correctly.

Group Materials
Plastic syringes (10 cc, 20 cc, 60 cc)
Plastic tubing (wait to get the syringes to see what will fit)
Wood Scraps
Cardboard
Bolts, Screws, Nuts, Washers, Nails, zip ties, fasteners
Other approved items
Drill (for teacher use or under supervision of the teacher)
Saw (for teacher use)
Safety glasses
Hammer
Tape

Instructions

1. Research possible solutions to this challenge. Look for pictures of robotic arms etc.
2. Using sketches, design a machine to solve the problem.
3. Make a detailed, labelled, to-scale drawing of the design.
4. Construct a prototype and make note of any changes on your drawing.
5. Test your prototype and then make it fail. Make note of how long it takes to fail and make any further changes, noting them on your drawing.

You may refer to the following website when coming up with your design:
http://k12engineering.blogspot.ca/2006/01/hydraulic-arm-research.html

This activity is adapted from
https://www.teachengineering.org/view_activity.php?url=collection/wpi_/activities/wpi_hydraulic_arm_challenge/wpi_hydraulic_arm_challenge.xml.

Consolidation/Extension

The Fluids System Assignment (See Link) may be assigned after the first class period.

Each student will research and complete a mini-report/poster/presentation on a real life application of a fluid system. Students may pick examples of:

- Hydraulic systems
- Pneumatic systems

Each report/poster/presentation, should include:

1. What type of fluid system is being used? (From the list above)
2. What is the working fluid in the system?
3. How is the fluid pressurized in the system?
4. What industry is this system used in?
5. How does this fluid system work?
6. Why is a fluid system used rather than another kind of system for this application?
7. Are there disadvantages to using this fluid system?
8. At least one picture/diagram of the system at work.