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### **Lesson Focus**

This lesson demonstrates how a hydraulic pump works. Students work in teams to design and build a unique water fountain that employs a hydraulic pump.

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### **Lesson Synopsis**

Students explore a hydraulic pump through a demonstration. They build their own pumps and work in teams to design a water fountain.

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### **Age Levels**

10-18

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### **Objectives**

During this activity students will:

- ◆ Explore hydraulic pumps.
- ◆ Design & build a water fountain.
- ◆ Implement the engineering design process to solve the design challenge.



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### **Anticipated Learner Outcomes**

As a result of this activity, students will have:

- ◆ Explored hydraulic pumps.
- ◆ Designed & built a water fountain.
- ◆ Implemented the engineering design process to solve the design challenge.

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### **Lesson Activities**

Students discuss water fountains and pumps. Student teams then observe a demonstration of a hydraulic pump. Next they will design, build, test, and redesign their own unique water fountain. Each team will demonstrate their water fountain and share their responses to reflection questions.

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### **Resources/Materials**

- ◆ Teacher Resource Documents (attached)
- ◆ Student Worksheets (attached)
- ◆ Student Resource Sheets (attached)

#### **Water Fountain**

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## ***Alignment to Curriculum Frameworks***

See attached curriculum alignment sheet.

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## ***Internet Connections***

- ◆ Pascal's Principal and Hydraulic Press: (<http://hyperphysics.phy-astr.gsu.edu/hbase/pasc.html>)
- ◆ Pressure and Applications: ([www.answers.com/topic/pressure](http://www.answers.com/topic/pressure))
- ◆ More Pump Lessons: ([www.swe.org/iac/LP/pumps\\_04.html](http://www.swe.org/iac/LP/pumps_04.html))
- ◆ TryEngineering ([www.tryengineering.org](http://www.tryengineering.org))

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## ***Optional Writing Activity***

- ◆ Have students write a poem about a water fountain using figurative language.
- ◆ Have student write an essay about the impact that water fountains, pumps, and hydraulic technology has had in society.

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## **For Teachers: Teacher Resource**

### ◆ **Lesson Goal**

The goal of this lesson is for students to design, build, test, and redesign their own unique water fountain. Each team will demonstrate their water fountain and share their responses to reflection questions.

### ◆ **Lesson Objectives**

During this activity students will:

- ◆ Explore hydraulic pumps.
- ◆ Design & build a water fountain.
- ◆ Implement the engineering design process to solve the design challenge.

### ◆ **Materials**

#### **Water Fountain Design Challenge**

General supplies available to everyone on a resource table in the classroom.

- ◆ Two-liter plastic bottles (straight)
- ◆ One-liter plastic bottles (straight)
- ◆ More plastic bottles
- ◆ Plastic tubing (various diameters)
- ◆ Wooden skewers
- ◆ Straws (different sizes)
- ◆ Corrugated cardboard
- ◆ Plastic sandwich bags
- ◆ Clay
- ◆ Rubber bands
- ◆ Waterproof Tape
- ◆ Scissors
- ◆ Xacto knife (NOTE: for only the teacher to use)
- ◆ Towels
- ◆ Water
- ◆ Design Challenge Worksheet
- ◆ Plastic tubs

#### **Hydraulic Pump Demonstration (TEACHER)**

- ◆ Two-liter plastic bottle (straight)
- ◆ One-liter plastic bottle (straight)
- ◆ Plastic tubing
- ◆ Waterproof tape
- ◆ Corrugated cardboard
- ◆ Wooden skewers
- ◆ Clay
- ◆ Scissors
- ◆ Xacto knife (NOTE: for only the teacher to use)
- ◆ Water
- ◆ Pump Resource Sheet
- ◆ Plastic tub

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**For Teachers (continued):****◆ Time Needed**

- ◆ three to four 45 minute sessions

**◆ Procedure****Introduction (~1/2 hour)**

1. Ask students what kinds of water fountains they have seen and where they have seen them.
2. Have students take a minute to think about how a fountain works. Have each student sketch what he or she thinks the inside of a typical pump may look like. Next, in small groups, have students share sketches to determine the common themes or components of common themes. After giving teams enough time to discuss, each group will share with the class. Appoint one student as the class recorder. This student will be in charge of compiling a list of common ideas for pump components from the class discussion. The final list can be posted in the room as a reference for the design phase.
3. Handout the student Water Fountain Worksheet and have students take a minute to explain in writing how they think a pump works. Discuss with the class the several different types of pumps and principles.

**Hydraulic Pump Demonstration (~15 minutes)**

1. Demonstrate the hydraulic pump and discuss with the class.
2. See Pump Resource Sheet.
3. Discuss construction details of the pump with the students.

**Design/Build/Test/Redesign (~1-2 hours)**

1. Separate students into teams of 3-5.
2. Remind students to follow the engineering design process:
  - Brainstorm solution to the challenge
  - Choose best solution
  - Build the prototype
  - Test the prototype
  - Redesign prototype
  - Share the final design with class
3. Have students design, build, test and redesign their water fountain.

**Communicate (~1/2 hour)**

1. Each team will demonstrate their fountain and share their answers to the reflection questions.

**Water Fountain**

**For Teachers:  
Pump Resource**

How to Make the Hydraulic Press for the class demonstration



- ◆ Basic Set-up: Use two empty soda bottles one smaller than the other (sizes are a variable). Connect the two bottles with a clear plastic tube (diameter is a variable). Cutting the holes for the tube requires a Xacto knife. Place the basic set up into a flat tub for testing.
- ◆ Seal: Use waterproof tape to seal around the tube where it connects to each bottle. Test to make sure the seals are working and that there are no leaks.
- ◆ Pressure: The smaller bottle is the bottle you will add the water to and then apply the pressure. To help apply the pressure, create a “waterproof puck” out of cardboard. Measure the diameter of your smallest bottle and cut out corrugated cardboard circles slightly smaller for the puck. Combine about 6 cardboard circles by covering the group of them with waterproof tape. As soon as the water is applied to the smaller bottle use the puck to exert pressure. Push the puck down into the smaller bottle. (if your hand is too big to fit into the small bottle attached a wooden skewer into the puck and use it as a handle).
- ◆ Fountain: To keep the lesson as open-ended as possible, don’t add a fountain design into your demo. Simply show the basic set up and have them create their own innovative designs.

NOTE: There are many variables that increase the complexity of this challenge. The size of the small and large bottles, the size and height of the connecting tube, the amount of pressure exerted, and the location and pattern of holes/tubes for the fountain. If you want to decrease the complexity fix one or more variables.

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***Student Resource:  
Water Fountains***

Examples of Water Fountains



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**Student Worksheet:**

Take a minute to individually think about how a fountain works. Next sketch below or on another sheet of paper what you think the inside of a typical pump may look like.

SKETCH the inside of a typical pump.

Explain how you think a pump actually works:

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**Student Worksheet:**  
**Water Fountain Design Challenge****◆ Scenario**

The city received a financial gift from a resident with specific instructions to use the money to build a water fountain for the local park. The city has asked all schools to design and build a prototype of a water fountain. The fountain that functions successfully and is the most interesting will be chosen to be built for the park.

**◆ Design Challenge**

Design and build a creative water fountain.

**◆ Criteria**

All designs must:

- ◆ Function successfully.
- ◆ Be aesthetically pleasing.

**◆ Constraints**

All designs must:

- ◆ Use only the materials given.

**◆ Planning Stage**

Meet as a team and discuss the problem you need to solve. Then develop and agree on a design for your water fountain. You'll need to determine what materials you want to use.

Draw your design in the box below, and be sure to indicate the description and number of parts you plan to use.

Team members: \_\_\_\_\_

Brainstorm designs for your water fountain:

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***Student Worksheet (continued):  
Water Fountain Design Challenge***

Choose your best design and sketch it here:

◆ **Construction Phase**

Build your water fountain. During construction you may decide you need additional materials or that your design needs to change. This is ok – just make a new sketch and revise your materials list.

◆ **Testing Phase**

Each team will test their water fountain. If your design is unsuccessful, redesign and test again. Continue until you are happy with it. Be sure to watch the tests of the other teams and observe how their different designs worked.

Sketch your Final Design

**Water Fountain**



## For Teachers:

### Alignment to Curriculum Frameworks

**Note:** Lesson plans in this series are aligned to one or more of the following sets of standards:

- U.S. Science Education Standards ([http://www.nap.edu/catalog.php?record\\_id=4962](http://www.nap.edu/catalog.php?record_id=4962))
- U.S. Next Generation Science Standards (<http://www.nextgenscience.org/>)
- International Technology Education Association's Standards for Technological Literacy (<http://www.iteea.org/TAA/PDFs/xstnd.pdf>)
- U.S. National Council of Teachers of Mathematics' Principles and Standards for School Mathematics (<http://www.nctm.org/standards/content.aspx?id=16909>)
- U.S. Common Core State Standards for Mathematics (<http://www.corestandards.org/Math>)
- Computer Science Teachers Association K-12 Computer Science Standards (<http://csta.acm.org/Curriculum/sub/K12Standards.html>)

#### ◆ National Science Education Standards Grades 5-8 (ages 10 - 14)

##### **CONTENT STANDARD B: Physical Science**

As a result of their activities, all students should develop an understanding of

- ◆ Motions and forces
- ◆ Transfer of energy

##### **CONTENT STANDARD E: Science and Technology**

As a result of activities, all students should develop

- ◆ Abilities of technological design
- ◆ Understandings about science and technology

#### ◆ National Science Education Standards Grades 9-12 (ages 14-18)

##### **CONTENT STANDARD B: Physical Science**

As a result of their activities, all students should develop understanding of

- ◆ Motions and forces
- ◆ Interactions of energy and matter

##### **CONTENT STANDARD E: Science and Technology**

As a result of activities, all students should develop

- ◆ Abilities of technological design
- ◆ Understandings about science and technology

#### ◆ Next Generation Science Standards Grades 3-5 (Ages 8-11)

##### **Motion and Stability: Forces and Interactions**

Students who demonstrate understanding can:

- ◆ 3-PS2-1. Plan and conduct an investigation to provide evidence of the effects of balanced and unbalanced forces on the motion of an object.

##### **Engineering Design**

Students who demonstrate understanding can:

- ◆ 3-5-ETS1-1. Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.
- ◆ 3-5-ETS1-2. Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.
- ◆ 3-5-ETS1-3. Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.

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***For Teachers:  
Alignment to Curriculum Frameworks***

**◆ Next Generation Science Standards Grades 6-8 (Ages 11-14)  
Engineering Design**

Students who demonstrate understanding can:

- ◆ MS-ETS1-1 Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.
- ◆ MS-ETS1-2 Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.

**◆ Standards for Technological Literacy - All Ages  
Design**

- ◆ Standard 10: Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.