

PUMP IT UP!



GOAL

Students will build a gravity-driven water pump and learn how pumps work in terms of pressure and velocity. Students learn that engineers work in teams, using field work as well as math and science and then discussing their work products.

GRADE LEVEL

High School. Activity without calculations is adaptable for middle school.

DISCUSSION

Engineers use pumps to deliver a liquid or a gas to a specific place at a required rate. Liquids and gases are known as fluids. A pump is used to change the elevation, velocity or pressure of a fluid. In nature, a fluid will flow naturally from a high place to a low place (like a waterfall) or from a high pressure to a low pressure (from inside a balloon to the outside air). Its velocity is often a function of geometry (its shape) and the conditions around it. When a fluid is needed uphill from a source like a lake or pond at higher pressure than a source, or at a higher rate, an engineer will consider a pump to accomplish the task.

Note: Gravity is often mistakenly labeled a force when it is actually acceleration.

RESOURCE

For charts, worksheets, equations, and deeper background, visit <http://aspire.swe.org/images/stories/lesson-plans/Pumps.doc>

ACTIVITY ONE – SIPHON PUMP

(Caution: You may get wet)

Materials (for each team):

- Two Large Bowls or Containers – *Not Glass*
- 2.5 - 3' of Plastic Tubing
- Table
- Chair

Steps to Follow:

1. Fill one large container with water and place on the edge of a desk or table.
2. Put one end of tubing in the container and hold it over the other container on a chair next to the desk or table. Raise and lower the other end of the tubing



over the second container. Nothing will happen – there is no fluid in the tubing and nothing to make the fluid flow.

3. Keep the one end of the tubing submerged and gently suck at the tubing until water fills the tube. Cap the end and quickly bring it down below the level in the first container over the second container. The water will flow into the second container.
4. Have students change the velocities of flow by slowly raising and lowering the second end. Have them record observations. They should notice:

- The lower the second end is from the water level in the first container, the faster it will flow.
- If the second end of the tubing is raised above the water level in the first container, the water will run back down the tubing into the first container and all flow will cease. Students will have to reapply suction to get the flow started again.

Variation: As the water is flowing from container 1 to container 2, put both ends of the tubing under water and slowly lift container 2 above container 1. The flow will reverse itself and go from container 2 to container 1! To see this best, be sure to keep the tubing filled with fluid.

ACTIVITY TWO – FLOW RATES AND VELOCITIES

(Caution – You may get wet)

One of the functions of a pump is to deliver a required amount of fluid in a given time. The amount is usually measured as a volume, and the time is defined as seconds, minutes or hours. The volume flow rate is a measure of how much fluid is delivered in a specific time.

Materials (for each team):

- One or More 2 Liter Plastic Bottles
- Big Flat Pan with Sides
- Small Cylinder
- Duct Tape
- Tape Measure
- Stop Watch
- Awl or Another Sharp Pointed Tool
- Data Chart
- Calculator

Steps to Follow:

1. Carefully make small holes in the cylinder (middle - where the diameter is constant) part of the plastic bottle. If you are only using one, we recommend 1 hole about 1.5" down from the top of the cylinder and a second below it about 1" above the bottom part of the cylinder (about 3.5" from the bottom of the bottle). Cover holes with a piece of tape. Add water to the top of the cylinder part. If several bottles will be used, try different hole placements!
2. Prepare Data Collection Sheet. Take all necessary measurements. You will need:
 - Diameter of cylinder (you can get this by wrapping the tape

measure tightly around the cylinder and reading the circumference. This is equal to π times the diameter)

- Diameter of the hole(s)
- Distance from each hole to



the fluid surface

3. Have one person hold the cylinder under one of the holes and carefully pull down the tape to get a clear flow out of the hole as a second person turns on the stop watch as the flow starts (this may take some practice). Time the flow for 10 to 20 seconds – less for bigger holes, more for smaller holes. Push the tape back up to stop the flow and stop the watch at the same time.
4. Record the time in the proper column. Measure the height of the water in the cylinder and record that on your data sheet. Be careful to measure from the inside bottom of the cylinder to the fluid surface. Repeat steps 4 and 5 at least 2 more times for a total of at least 3 trials per hole. For best results, be sure to pour the water back into the bottle to the same fluid surface height for each trial. Repeat these steps for all other holes, recording the data as you go using the Data Collection Sheet.
5. In an area away from the bottles and the water, start calculating the values on the data sheet to get the flow rates and then the velocity of the flow at each hole. The flow rate, Q , is the volume of fluid in the cylinder divided by the

time in inches cubed per second. Take the average of the trials to use for the velocity calculation. The average is the sum total of the trial values divided by the number of trials. This averaged flow rate is divided by the area of the hole to get the fluid velocity at that hole.

6. Discuss your results with others. The lower the hole is on the bottle, the higher the fluid velocity should be. How do your results compare?

CONNECT TO ENGINEERING

In locations where electricity is not available or unreliable (ask for examples), and water is needed at a distance from its source, engineers use the concept explored in activity two to make a gravity powered pump. This means a remote village could for the first time get a dependable water supply without the necessity of hand carrying water jugs all day.



This activity based on "PUMPS," from the Society of Women Engineers.

Developed in collaboration with Education Development Center, Inc.

The Society of Women Engineers is a member of the National Engineers Week Foundation Diversity Council.



ENGINEERS WEEK 2013
FEBRUARY 17-23
www.discoverengineering.org