Mechanical Pump Activity
Instructor Guide

Notes to Instructor

The Diaphragm Pump Activity provides the participants an opportunity to explore diaphragm pumps. This activity is one of two activities provided in the *Micropumps Overview Learning Module*. The units contained in the *Micropumps Overview Learning Module* can be presented in any order; however it is recommended that the students read the Micropumps Overview Primary Knowledge first.

Following are the units included in the *Micropumps Overview Learning Module*.

- Micropumps Overview Knowledge Probe
- Micropumps Overview Primary Knowledge
- **Diaphragm Pump Activity**
- Capillary Action Activity
- Micropumps Overview Final Assessment

Description and Estimated Time to Complete

In this activity, you design and build a diaphragm pump model which uses check valves and a pumping membrane. The pump you build must simulate a mechanical type micropump. Building this model will help you gain a physical understanding of the operation of these common types of pumps.

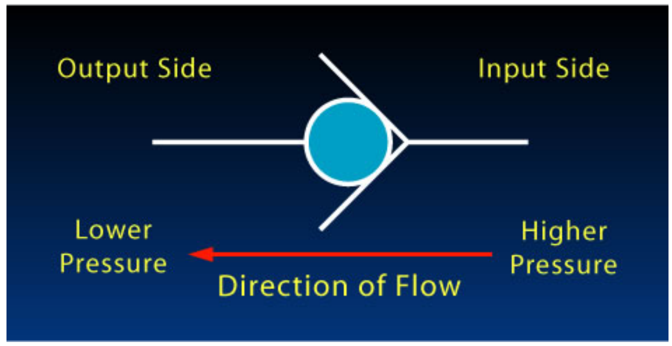
If you have not reviewed the unit *Micropumps Overview*, you should do so before completing this activity.

<u>Estimated Time to Complete</u>
Allow at least two hours to complete this activity.

Introduction

We have all used a pump in one form or another. You've used a pump to put air in your tires and vacuum your carpet. Most common everyday pumps have moving mechanical parts. Pumps move a fluid (a liquid or a gas) from one place to another and from a high pressure zone to a lower pressure zone. As long as the pressure different exists, fluid flows. Once the pressure equalizes, the flow stops.

The theory of operation of most pumps is to increase a fluid's pressure and cause it to flow. An example of this is a bicycle pump. Bicycle pumps are pumps that use check valves. Check valves are valves that allow flow in only one direction – from an input to an output. This is the symbol for a check valve.



When considering the operation of a bicycle pump, the air flow is only allowed from the input to the output. Bicycle pumps operate using energy input from the operator. The operator moves the handle of the pump up and down. The up-stroke decrease pressure and thus draws air in, while the down-stroke increases pressure pushing air into the tire.

A detailed explanation of a bicycle pump is provided in Micropump Overview. If you are unclear on how a bicycle pump works, please go back and review the overview. In this activity you will design and build a pump that simulates the action of a bicycle pump which is the same action found in most diaphragm micropumps.

Activity Objectives and Outcomes

Activity Objectives

- Design and construct a pump that uses check valves and a diaphragm (membrane).
- Describe the operation and applications of at least one type of micropump.

Activity Outcomes

To produce a working model which illustrates how a diaphragm pump works.

Facilities / Workspace / Safety Precautions

You will need a table as a workspace, and it is best to cover the table to protect it while you are working on your model.

Suggested Supplies / Equipment

- Plastic pitre dish or some wide, short dish
- Straws
- Scissors
- Glue
- Plastic wrap
- Sheet of paper
- Tape

Teamwork

It is recommended that the participants work in small teams to complete this activity. Working in teams will promote core competencies such as teamwork, problem-solving and troubleshooting.

Activity: Diaphragm Pump

Procedure:

1. As a team discuss the operation of a check valve pump such as a bicycle pump. Ensure that everyone on the team understands the theory of operation.
2. Using the supplies and tools provided (or additional tools if needed), design and build a diaphragm pump.
3. Your design and model should meet the following criteria:
    a. Use a membrane to initiate the movement of air through the pump by creating a high and low pressure
    b. Correctly use at least two check valves that allow and block the flow of air to and from different zones.
        i. The input valve should allow air into a pump chamber on the intake.
        ii. The output valve should allow air out of the pump chamber on the outtake, but not allow air in.
4. Draw a diagram of your pump that shows all of its parts and which illustrates the operation of the pump.
5. Answer the Post-Activity Questions.

Final Design

The following is an example of what a diaphragm pump could look like

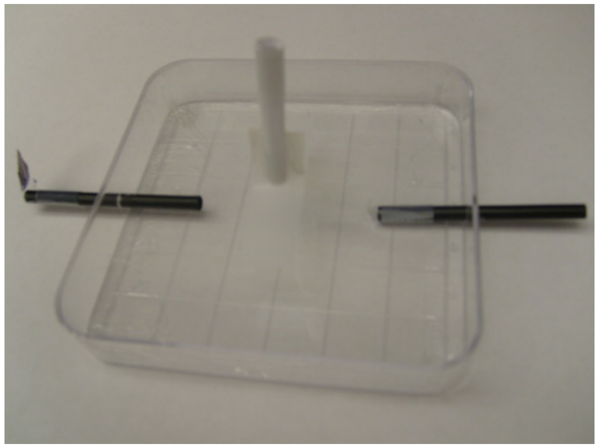


Image of diaphragm pump. Transparent plastic wrap is stretched over a pitre dish and actuated by the paper tube attached at its center point. The paper tube acts as the pump handle. The check valves are the black straws with plastic wrap at one end. The valve on the right has a plastic wrap flap on the straw end that is inside of the pump. This valve acts as the input valve because it allows air in the pump on the intake. The straw on the left has a plastic wrap flap on the straw end that is on the outside of pump, and this valve acts as the output valve. This valve allows air out on the outtake but closes during the intake.

Post-Activity Questions

1. Describe the operation of the diaphragm pump.

2. One of the characteristics of micropumps is that leakage is negligible compared to that of a macro-size pump.
   a. Why is leakage more of a problem in macro-pumps than in micro-pumps?
   b. Why is it important to have good seals throughout a pump?
   c. In your pump design, describe the areas in which leaks could occur and the effect that each leak could have on the pump's operation.

3. Research mechanical micropumps. Describe the operation of at least micropump and discuss its applications. Provide a diagram or images of the pump if possible. Be sure to include references and sources in your discussion.

Post-Activity Questions / Answers

1. Describe the operation of the diaphragm pump.
   Answer: On the up-stroke, a low pressure is created in the pump chamber and air is drawn through the input check valve where the atmospheric air is at a higher pressure. On the down-stroke, the pressure of the air in the pump chamber increases, thus driving air through the output valve.

2. One of the characteristics of micropumps is that leakage is negligible compared to that of a macro-size pump.
   a. Why is leakage more of a problem in macro-pumps than in micro-pumps?
      The parts in a macro-pump are bigger, the pressures higher thus creating leakage problems. In a micro-pump, the seals are in the micro or even nano-range and the fluid volumes and pressures are small; therefore, leaks are less likely.

   b. Why is it important to have good seals throughout a pump?
      Leak could prevent the buildup of pressure within the pump, thus preventing flow. Leaks could also cause the fluid to flow in the wrong direction or in multiple directions. Leaks could allow fluid to escape during operation causing lower than expected outputs and, depending on the fluid between transfer, causing a hazardous situation due to hazardous fluid leak.

   c. In your pump design, describe the areas in which leaks could occur and the effect that each leak could have on the pump's operation.

3. Research mechanical micropumps. Describe the operation of at least micropump and discuss its applications. Provide a diagram or images of the pump if possible. Be sure to include references and sources in your discussion.

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