

**Civil Engineering - Fluid Mechanics I**  
**Design Project**  
**Fall 2002**

In this course, in addition to learning the basics of fluid hydrostatics and fluid motions through lectures, labs, and homework exercises, you will learn through hands-on fabrication and testing of a positive displacement pump.

**Background**

One type of positive displacement pump uses a piston moving in a cylinder to “push” fluid along a pipe. As the piston is drawn out of the cylinder, a region of low pressure is developed. Fluid is admitted into the cylinder through a one-way “check” valve. As the piston moves back in to the cylinder, the inlet check valve closes, and an outlet check valve opens, allowing fluid to escape the cylinder.

A schematic of a single-acting piston pump is shown in Figure 1.

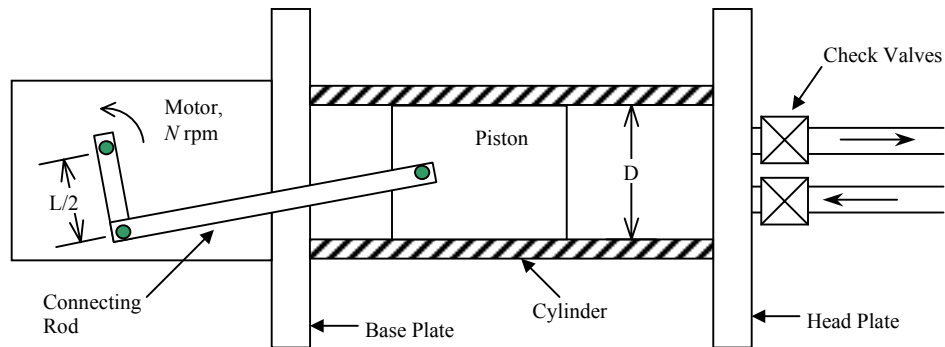


Figure 1: Horizontal single-acting piston pump (ref, Orlins & Constans, 2001)

A more complex pump moves fluid on both the in- and out-strokes of the piston, as shown in Figure 2.

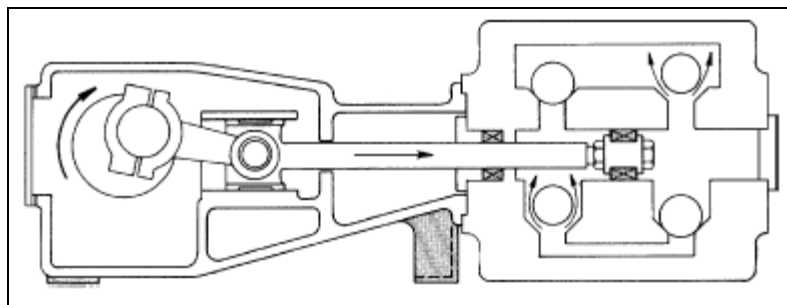


Figure 2: Horizontal double-acting piston pump. (ref: Hydraulic Institute, 2000)

Working with a group of your classmates, you will build (from scratch) a piston pump, using parts supplied to you. Your finished pump may look something like the one shown in Figure 3.

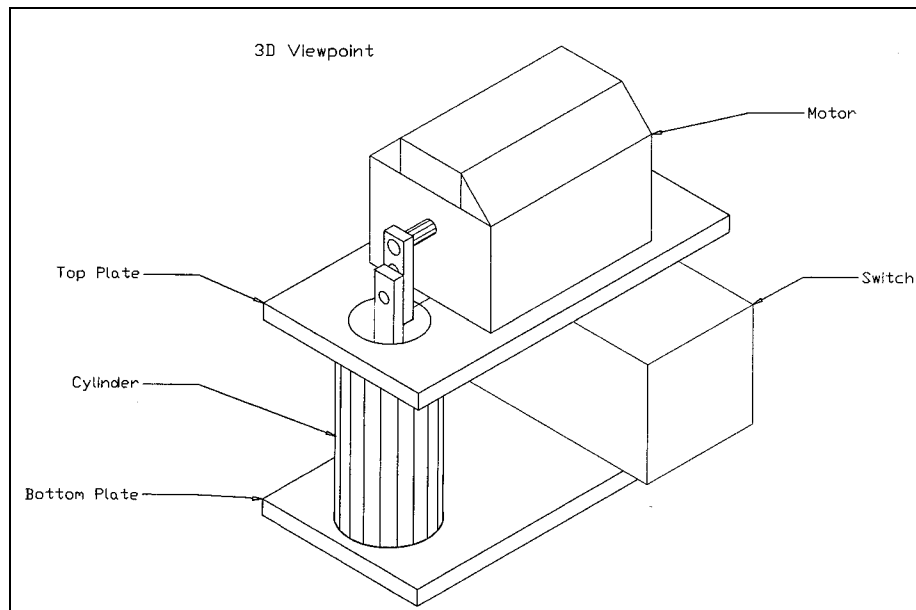


Figure 4: Schematic of completed pump (Orlins & Constans, 2001).

## Educational Goals

In order to complete the positive displacement pump project successfully, you will need to understand and/or make use of the following topics and skills:

### Fluid Mechanics

- (a) Introduction to turbomachinery
- (b) Control volumes, application of continuity
- (c) Head-discharge relationships for positive displacement pumps

### Mechanical Design

- (d) Design of a linkage to perform a specific task

### Prototyping Skills

- (e) Transfer of theoretical design into physical design
- (f) Fabrication of pump parts in the Rowan Machine Shop
- (g) Design testing / evaluation / improvement

## Design Problem Statement

A positive displacement pump has a piston diameter of  $D$ , as shown schematically in Figure 1. The piston is attached to a slider-crank mechanism with a crank length of  $L/2$ . The total distance the piston moves in one direction is the “stroke length,”  $L$ . The crank is attached to a variable speed motor, which rotates at speed  $N$ .

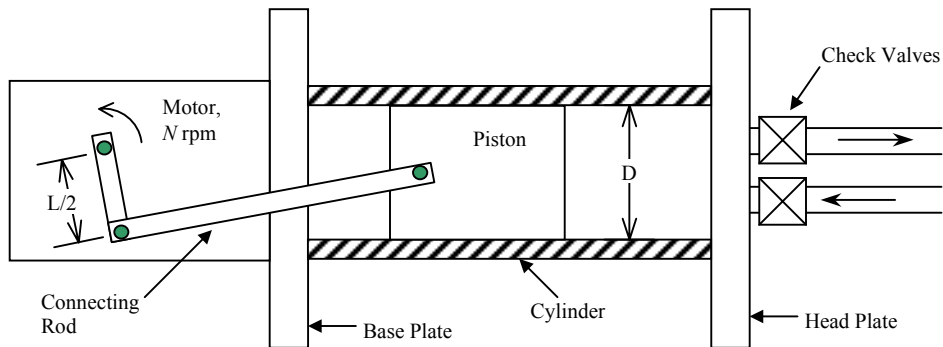


Figure 1 (repeated): Nomenclature and definition sketch for pump

### 1. Individual Exercise: **Due 26 September 2002**

- a. Calculate and plot the pump discharge as a function of cylinder diameter ( $D$ ), piston stroke length ( $L$ ), and motor speed ( $N$ ). Use diameters of  $D = 0.5, 1.0, 1.5,$  and  $2.0$  inches; stroke lengths of  $0.5, 1.0,$  and  $1.5$  inches; and motor speeds ranging from  $0$  to  $200$  rpm. Set up your plots showing discharge as a function of motor speed; this will result in a “family” of twelve curves for the different diameter / stroke combinations.
- b. Submit your nomination for a team of two other people to work with for the remainder of the project.

### Group Project: (due 24 October 2002)

2. Design and build a positive displacement pump to provide 1 liter per minute of water.
3. Make engineering drawings of all the parts you made for your pump, including:
  - a. Head plate
  - b. Motor mounting plate
  - c. Cylinder
  - d. Piston
  - e. Connecting rod
  - f. Any additional parts you made

Each drawing should include three views (orthographic projection) of the part and all dimensions. The drawings should be made on a computer. Make an assembly drawing, showing all the parts together. An example assembly drawing is shown in Figure 1.

4. Test your pump. Determine its maximum flow rate,  $Q_{\max}$ , and maximum output head,  $H_{\max}$ .
5. Complete a 2-page write-up of the pump project. Include a bill of materials needed to build a positive displacement pump (including fasteners). In the write-up, describe your design and characterize its performance. How would you improve your design?

### Grading:

Your grade for this project will be counted as part of your laboratory grade. To receive a satisfactory grade for this project, you must:

- a. Complete the individual homework assignment described above;
- b. Participate actively in your group to design, build, test, revise, and document your pump;
- c. Be prepared to answer any questions regarding the project that an instructor or interested individual might ask;
- d. Provide both a self-evaluation and peer-evaluation.

### References:

Hydraulic Institute, 2000. *Standards for Reciprocating and Power Pumps*.

Orlins, J.J., and Constans, E.W., 2001. "Hands-on Design and Manufacturing in an Undergraduate Fluid Mechanics Course," 2001 Annual ASEE Conference, Albuquerque, NM.