CEE 342 Laboratory Exercise: Energy Equation Demonstration

In this laboratory, measurements will be taken of pressures at the inlet and outlet of a centrifugal pump, and of the flow rate of water through the pump, when the pump is supplied with several different levels of power. The piping dimensions needed for the calculations are shown schematically in Figure 1. The discharge gage reads in psig, and the suction gage reads in inches of mercury vacuum. The discharged pressure gauge is 2 ft, 11 in above the middle of the pipe. The pipe leading to the gauge is filled with water, and the gauge reads the pressure of the water at the top of that pipe.

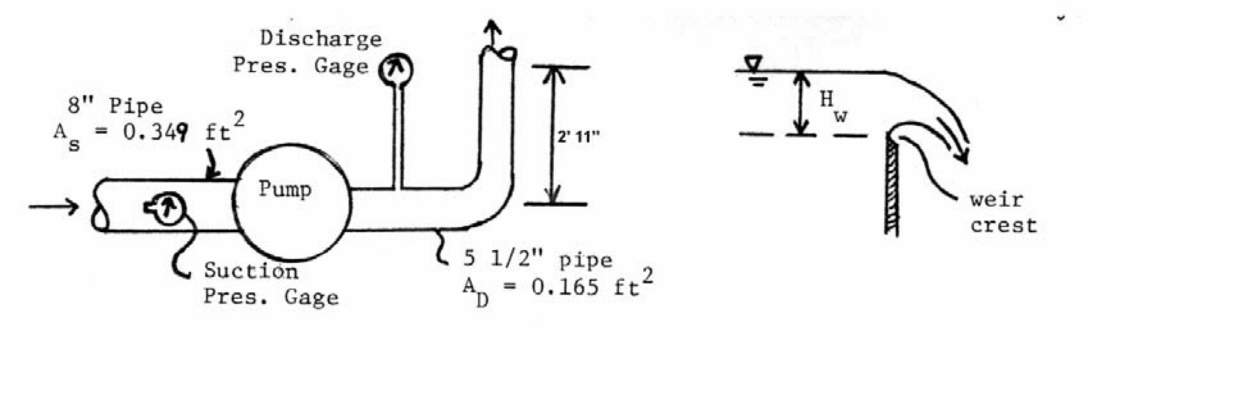

Figure 1. Schematics showing (a) the centrifugal pump, associated piping and gauges, and (b) definition of terms associated with the weir.

An overall schematic of the entire experimental system is shown in Figure 2. The loop starts at the asterisk (*). Water enters the pipe from the reservoir, passes through the suction gage, and is pumped up to the tank on the upper floor. The flow is steady for any given test run, but can be changed between runs by adjusting a valve in the pipe downstream of the pump. The water that enters the tank quickly fills the tank, and excess water flows over the weir back down to the reservoir.

Figure 1b shows the location of the weir crest and the height of the water, H_w, above the weir crest. Note that H_w is defined by the height of water upstream of the weir. A hook gage measures H_w. The rectangular weir is 2 feet wide. The weir equation is:

$$Q = C_w B H_w^{1.5}$$

where Q is in cubic feet per second, B is the weir width (= 2 ft), H_w is in feet, and $C_w = 3.33$. This is an empirical equation applicable to rectangular weirs.

Set up a data table that includes Run #, Pump Inlet Vacuum (inches Hg), Pump Discharge Pressure (psig), Pump Input Power (kW), and Hook Gage reading (ft) [note: the hook gage is graduated in fractions of a foot, not in inches!]. For the first run, record the power supplied to the pump and the suction and discharge pressures with the discharge valve completely closed, i.e., for $Q = 0$. Also take a reading of the hook gage under these conditions, with the water level at the height of the weir ($H_w = 0$). Then, make six runs with $Q > 0$, varying the flow rate from run to run using the valve such that the hook gage readings range from about 1.2 to 1.8 feet.

Some information that might be useful about the architecture of the building is as follows:

Floor to floor -- 11 ft, 0 in

First floor to weir top -- 14 ft, 6 in

First floor to the center of the pipe entering the pump -- 1 ft, 3.5 in

You will also need to know the distance from the top of the reservoir to the first floor; you should measure this distance.

The calculations you should make for each flow rate tested include:

- the flow rate Q
- the total head added to the water by the pump, H_p
- the efficiency of the pump + motor setup
- the velocity of the water (the overall velocity, and also the vertical and horizontal components) as it passes the mezzanine floor after passing over the weir; for this calculation, assume that the height of the water above the weir is the same as the height that was measured upstream using the hook gage
- the expected pressure in the suction end of the pump

The efficiency of the pump + motor is the ratio of the power acquired by the water to the electrical power supplied to the motor, expressed as a percentage. The velocity of the water passing the mezzanine floor is an application of Bernoulli's principle for open jets. The expected pressure in the suction end of the pump is another application of Bernoulli’s principle, this time for flow through pipes.

In your discussion, you should note any trends you observe for the total head and the pump efficiency and state briefly why you think they exist. Also, compare your calculated result for the expected pressure with the pressure shown on the gage and suggest reasons for any difference between these values.

The general requirements for the write-ups for Labs #3-5 are on the Labs web page. Please include a title sheet and your laboratory data sheet in your report.

Lab 3 Grading

Report Section	Points Possible
Title Sheet	--
Lab data sheet	--
Introduction	2
Flow rate, Q (ft^3/s)	3
Pump Head, H_p (ft water)	3
Pump Horsepower	3
Combined Efficiency of Pump and Motor (%)	3
Water velocity in weir jet	3
Discussion	3
TOTAL	20

(Sample calculations required for all of the above)

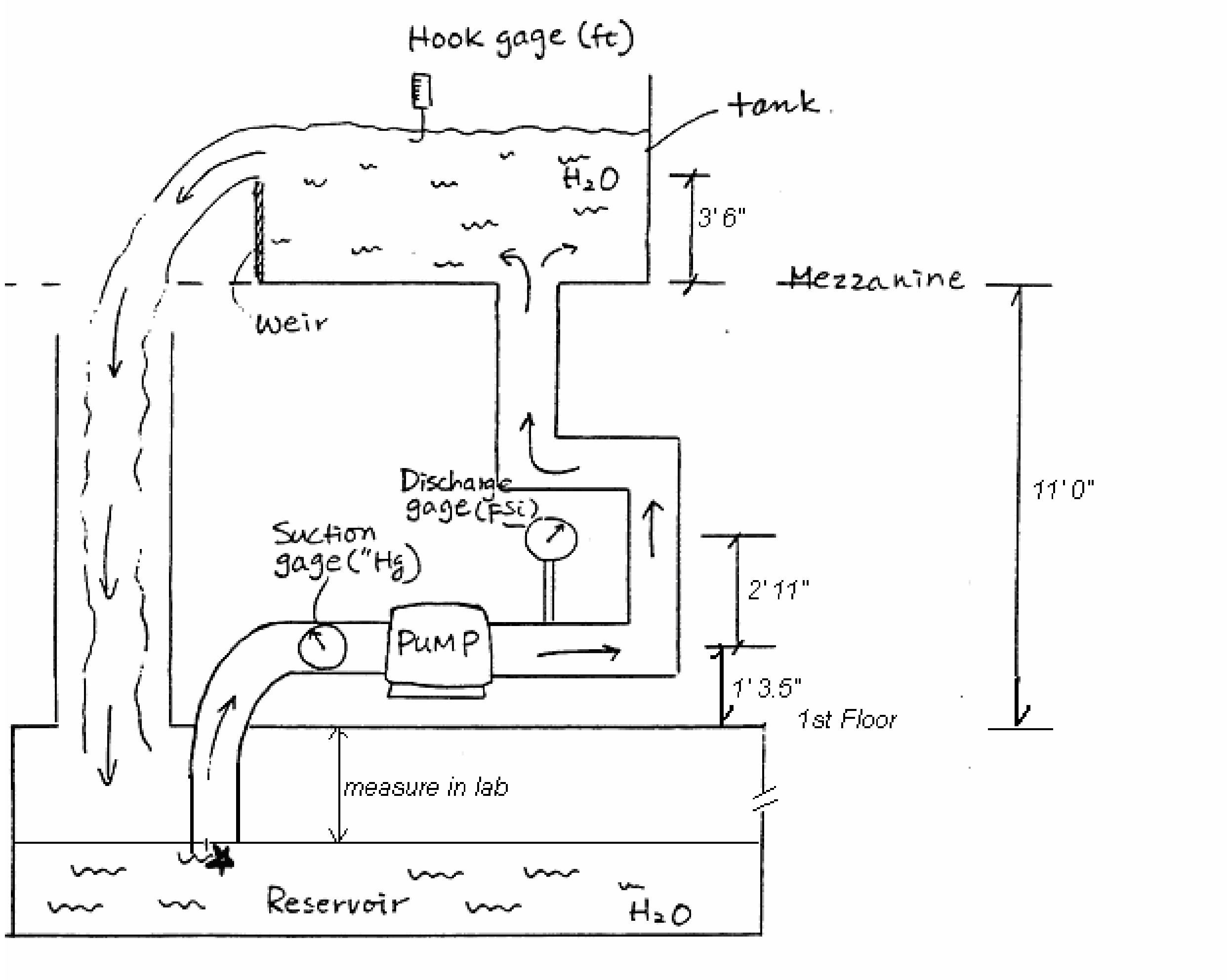

Figure 2. Overall schematic of the experimental system.