<u>Flow-meter (Rotameter) Calibration</u>

It is common to assume that measurement instrumentation is properly calibrated and that fluctuations in the readings are not excessive. However, errors or uncertainties are always present when experimental measurements are taken. These errors can result from human inconsistencies and/or improper calibration or uncertainties in instrumentation devices. Take for example flow-meters (rotameters) that are usually factory calibrated for use with a specific fluid under certain ambient temperature and pressure conditions. The use of these devices with a different fluid or under varying temperature and pressure conditions will require that these devices are re-calibrated to ensure that accurate measurements are taken.

The following handout describes the procedure for calibrating rotameters in a laboratory setting.

<u>Uncertainty</u>: a margin of error of a measurement stated by giving a range of values likely to enclose the true value.[1]

<u>Experimental Procedure:</u>

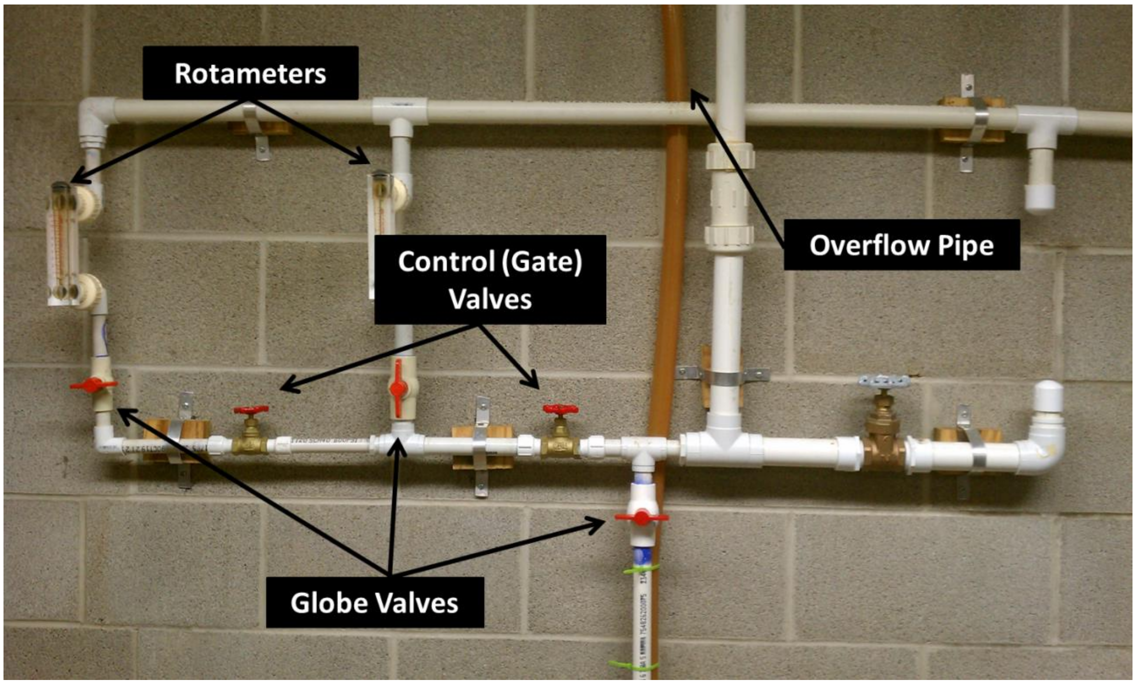
Fill the bottom open tank with water until it is ¾ full. Make sure that all the valves are in the closed position. Turn on the pump, and let the top tank fill with water until it is overflowing (water is coming out of the clear pipe).

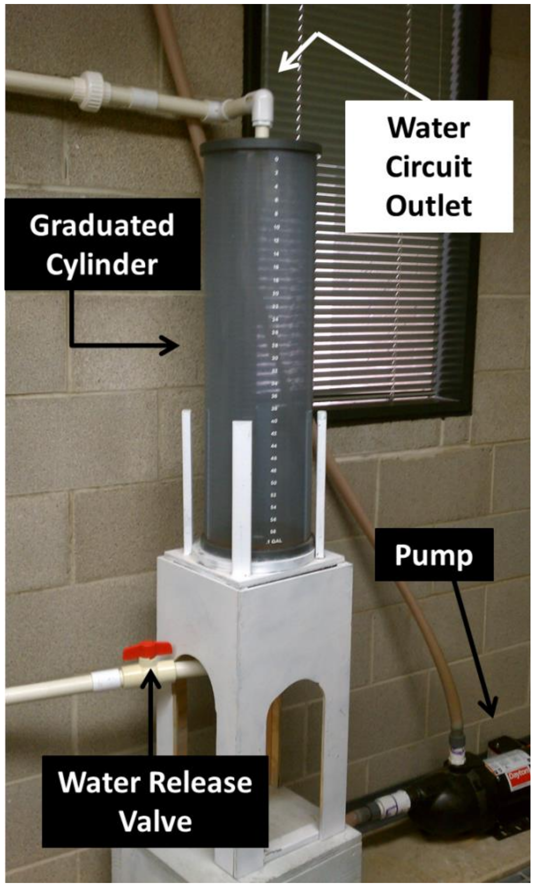
The flow-meter (rotameter) on the far left side measures from 0.1 GPM to 1 GPM in 0.1 GPM increments. The rotameter on the right side measures from 0.2 GPM to 3.2 GPM in 0.2 GPM increments.

Adjust the red globe valves so the circuit for the flow-meter (rotameter) to be calibrated is open. Using the red gate valves, control the volume flow rate through the applicable rotameter in appropriate increments. Time how fast it takes to fill the graduated cylinder on the right to the desired volume with an accurate stopwatch. Once the graduated cylinder has filled to the target volume, record the volume and time in the provided table, and open the release valve on the pipe

[1] http://en.wikipedia.org/wiki/Uncertainty

located at the bottom of the graduated cylinder to let the water out. Repeat this process for every indicated flow rate in the data tables provided. The uncertainty in volume flow rate should not be greater than 0.1 GPM (see equation on next page). If the uncertainty in volume flow rate is greater than 0.1 GPM, the flow rate will have to be remeasured until the appropriate uncertainty is achieved.





Analysis:

The following equation is used to determine the uncertainty in the experimentally acquired volume flow rate measurement:

$$U_{\dot{V}} = \dot{V}\left[\left(\frac{U_{\forall}}{\forall}\right)^2 + \left(\frac{U_t}{t}\right)^2\right]^{\frac{1}{2}}$$

$U_{\dot{V}}$: uncertainty/error in your experimentally acquired volume flow rate, $\dot{V}$.

$U_{\forall}$: uncertainty/error in the volume measurement, $\forall$.

U_t : uncertainty/error in the time measurement, t.

Calculate your experimental volume flow rate, the uncertainty in your experimentally acquired volume flow rate, and the minimum and maximum values of your experimental uncertainty. Produce a plot of the experimentally acquired volumetric flow rate versus the rotameter volumetric flow rate. Be sure to add the uncertainty or error bars to the obtained calibration curve. Provide a calibration equation and discuss your findings and conclusions. Also, compare the accuracy of the two rotameters within the same volume flow rate range. Produce a plot showing the effect of keeping volume constant on the uncertainty of the volume flow rate by means of the volumetric flow rate.

Data Table:

Rotameter on Right			Rotameter on Left		
Rotameter Volumetric Flow Rate (GPM)	Volume (Gallons)	Time (min)	Rotameter Volumetric Flow Rate (GPM)	Volume (Gallons)	Time (min)
0.2			0.2		
0.4			0.4		
0.6			0.6		
0.8			0.8		
1.0			1.0		
1.2					
1.4					
1.6					
1.8					
2.0					
2.2					
2.4	3.5				
2.6	3.5				
2.8	3.5				
3.0	3.5				
3.2	3.5				