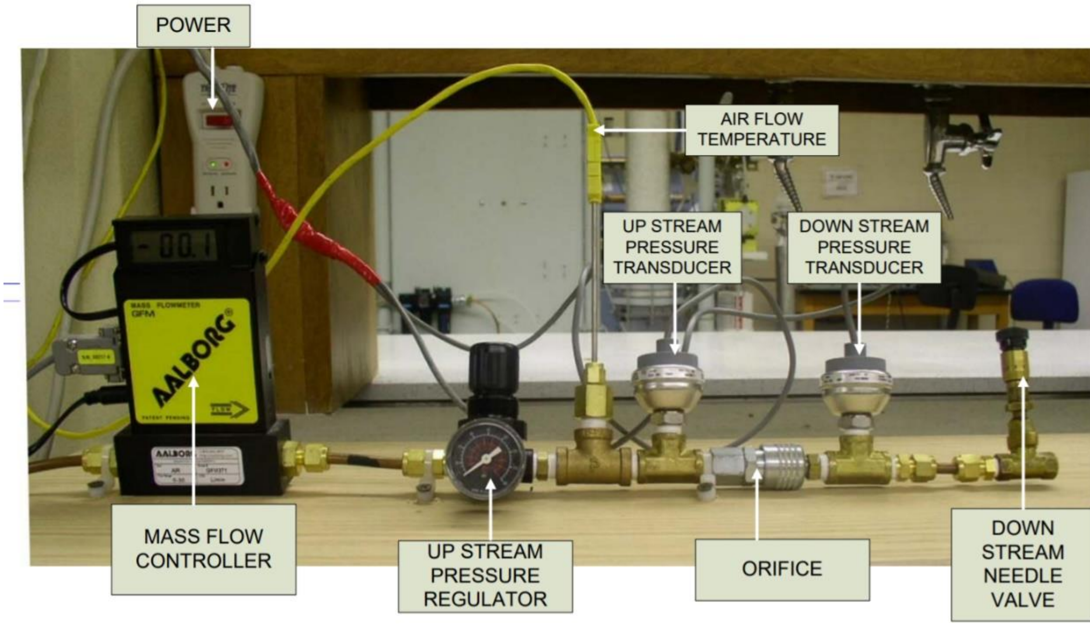

1. The above apparatus is the choked flow experiment you may do as part of UO Lab next semester. Pressurized, room temperature air flows through a 1mm inner diameter orifice and out into the room. Gauge pressure before and after the orifice are measured by pressure transducers. In this experiment, you can change the downstream pressure while maintaining the upstream pressure constant until your mass flow rate through the orifice reaches its maximum value. Because Provo is at a higher elevation than most places, atmospheric pressure is 86 kPa. You may assume that room temperature is 25°C and that the molecular weight of air is 29.0 g/mol.

   a) At what ratio of downstream to upstream pressure will the flow be choked?
   b) Sketch a graph of mass flow rate of air through the orifice versus the ratio of downstream to upstream pressure. What does this tell you about choked flow? When would it be useful to have choked flow? Hint: The mass flow rate should increase with a greater pressure drop.
   c) On our last homework, we derived an equation for choked flow mass flow rates which can be rewritten in the following form:

   $$\dot{m} = C_d A \sqrt{\gamma \rho_0 P_0 \left(\frac{2}{\gamma+1}\right)^{\frac{\gamma+1}{\gamma-1}}}$$

   Where C_d is the discharge coefficient which is the ratio of the real flow through the orifice to the theoretical flow through the orifice. You may assume that the discharge coefficient is 0.99 (you will experimentally determine it in UO Lab). What is the maximum real mass flow rate through the orifice at an upstream pressure of 50 psig? What flow regime does this fall under?
   d) Assuming the flow in the pipe to be cylindrical Poiseuille flow, write out the appropriate Navier Stokes equation and simplify it. Can you solve this simplified form using appropriate boundary conditions?