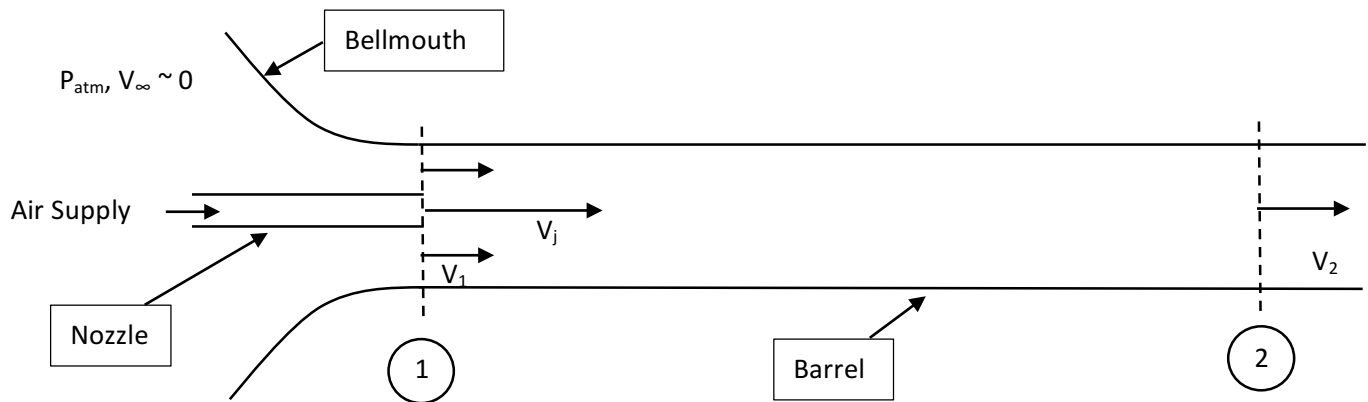


Consider the sketch.



A device is used to aspirate air and eject the air stream into a downstream pipe. The device consists of a barrel (cross sectional area  $A_0$ ) and a small diameter nozzle (cross sectional area  $A_j$ ) positioned on the axis of the barrel near the inlet. The nozzle is attached to an air supply. The barrel is open to the atmosphere ( $p_{\text{atm}}$ ) at the inlet (as shown) and is attached to a pipe located downstream of section 2. The flow throughout may be assumed steady and incompressible. The velocity of the air at the nozzle exit,  $V_j$ , is uniform over  $A_j$  as is the velocity at the location 2,  $V_2$ , over  $A_0$ . Similarly, the velocity of the aspirated air,  $V_1$ , may be assumed uniform over the annular area ( $A_0 - A_j$ ). Assume there is no shear stress acting along the walls of the barrel. Note that at the inlet to the bellmouth the velocity may be assumed to be negligibly small and the pressure is atmospheric.

- (15 pts.) Using the nomenclature given above, derive an expression relating  $V_1$  to  $p_{\text{atm}}$ ,  $p_1$ , and the density,  $\rho$ .
- (10 pts.) Using the nomenclature given above, derive an expression relating the exit velocity,  $V_2$ , to the aspirated air velocity,  $V_1$ , nozzle velocity,  $V_j$ , and the relevant areas.
- (50 pts.) Assuming the pressure,  $p_1$ , is uniform over the entire cross section (including both the annular area  $A_0 - A_j$  and  $A_j$ ) determine an expression relating  $p_2$  to  $p_1$ ,  $V_1$ ,  $V_j$ ,  $V_2$ ,  $\rho$ , and the various  $A$ 's.
- (12 pts.) Given the following values determine the value of  $p_2$  (as a gage pressure in kPa).
  - $A_0 = 4.90 \times 10^{-4} \text{ m}^2$
  - $A_j = 1.00 \times 10^{-4} \text{ m}^2$
  - $V_j = 100.0 \text{ m/s}$
  - $V_1 = 6.10 \text{ m/s}$
  - $\rho = 1.20 \text{ kg/m}^3$
  - $p_1 = -22.3 \text{ Pa}$  (gage pressure)
- (5 pts.) What is the “cause” of the change in pressure from the atmosphere through the bellmouth to  $V_1$ ?
- (8 pts.) How is the “cause” of the change in pressure through the barrel different from that through the bellmouth?