FAS 361 Fall 2008

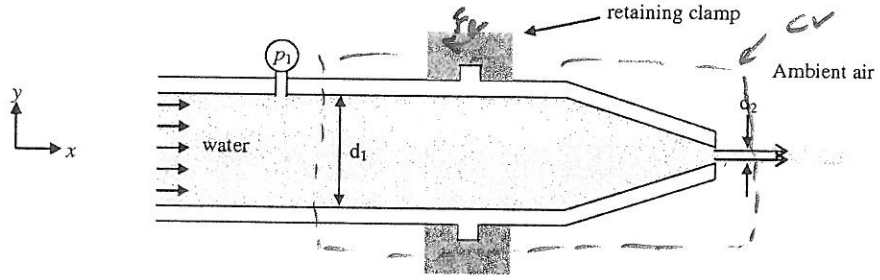
Name_____

Final Exam

Closed book, closed lecture notes. 2-page cheat sheets, equation sheets, and calculator allowed.

1. (35pts) Water from a pipeline flows through the axisymmetric nozzle depicted in the sketch. The jet of the water leaving the nozzle flows into the ambient air. A ridge around the external circumference of the nozzle provides a surface for attaching an annular retaining clamp that holds the nozzle in place. The volumetric flow rate Q, the dimensions d_1 and d_2, and the reading on the pressure gage p_1 are known. Neglect the weight of the water.

a) (15pts) Derive a formula (of known terms) for the horizontal force on the retaining ring.
b) (5pts) Under what conditions would the nozzle move to the right if the clamps were removed?
c) (10pts) Derive a formula (of known terms) for the head loss for the flow through the nozzle.
d) (5pts) Is there a value of p_1 that would make the head loss zero? If so, what is it?



A) Apply linear momentum in x direction - assume steady flow $A_1 = \pi \frac{d_1^2}{4}$

$$\sum F_x = \int_{CS} \rho V_x (V \cdot n)\, dA \qquad A_2 = \pi \frac{d_2^2}{4}$$

$$Q = V_1 A_1 = V_2 A_2$$

without velocity profile lets use average velocities.

RHS $\rho(V_1)(-V_1)A_1 + \rho V_2 (V_2) A_2 = -\rho \frac{Q^2}{A_1} + \rho \frac{Q^2}{A_2} = \rho Q^2 \left[\frac{1}{A_2} - \frac{1}{A_1}\right]$

LHS $P_1 A_1 - P_2 A_2 - F_R = P_1 A_1 - F_R$ since P_2 is ambient

so

$$P_1 A_1 - F_R = \rho Q^2 \left[\frac{1}{A_2} - \frac{1}{A_1}\right]$$

$$F_R = -\rho Q^2 \left[\frac{1}{A_2} - \frac{1}{A_1}\right] + P_1 A_1$$

B) moves to right if $F_R > 0 \Rightarrow P_1 A_1 > \rho Q^2 \left[\frac{1}{A_2} - \frac{1}{A_1}\right]$