EAS 361 Quiz 3 28 November 2006

Print Your Name: _____

Sign Your Name: _____

This exam booklet contains

1. This cover sheet.
2. A double-sided, single sheet of paper with four quiz questions.

Do not open the exam booklet until you are instructed to do so.

You will have 30 minutes to complete the quiz.

Universal Cheat Sheet

Properties of Water at 20 °C:

$$\rho = 999\ \frac{\text{kg}}{\text{m}^3} = 1.94\ \frac{\text{slugs}}{\text{ft}^3} \qquad \mu = 1.12 \times 10^{-3}\ \frac{\text{N}\cdot\text{s}}{\text{m}^2} = 2.34 \times 10^{-5}\ \frac{\text{lb}_\text{f}\cdot\text{s}}{\text{ft}^2}$$

Properties of Air at 1 atm and 20 °C:

$$\rho = 1.23\ \frac{\text{kg}}{\text{m}^3} = 2.38 \times 10^{-3}\ \frac{\text{slugs}}{\text{ft}^3} \qquad \mu = 1.79 \times 10^{-5}\ \frac{\text{N}\cdot\text{s}}{\text{m}^2} = 3.74 \times 10^{-7}\ \frac{\text{lb}_\text{f}\cdot\text{s}}{\text{ft}^2}$$

Basic Constants

$$R_u = 8.314\ \frac{\text{kJ}}{\text{kmol}} = 1545\ \frac{\text{ft}\cdot\text{lb}_\text{f}}{\text{lbmol}\cdot\text{R}} \quad R_\text{air} = 286.9\ \frac{\text{J}}{\text{kg}\cdot\text{K}} = 1716\ \frac{\text{ft}\,\text{lb}_\text{f}}{\text{slug}^\circ\text{R}} \quad g_c = 32.174\ \frac{\text{lb}_\text{m}\,\text{ft}}{\text{lb}_\text{f}\,\text{s}^2}$$

Conservation Principles:

$$0 = \frac{\partial}{\partial t}\int_{CV} \rho\, d\mathcal{V} + \int_{CS} \rho(\mathbf{V}\cdot\hat{\boldsymbol{n}})\, dA$$

$$\sum \mathbf{F} = \frac{\partial}{\partial t}\int_{CV} \mathbf{V}\,\rho\, d\mathcal{V} + \int_{CS} \mathbf{V}\rho(\mathbf{V}\cdot\hat{\boldsymbol{n}})\, dA$$

$$\dot{Q}_{\text{net,in}} + \dot{W}_{\text{shaft,in}} = \frac{\partial}{\partial t}\int_{CV} e\,\rho\, d\mathcal{V} + \int_{CS}\left(h + \frac{V^2}{2} + gz\right)\rho(\mathbf{V}\cdot\hat{\boldsymbol{n}})\, dA$$

$$\left(\frac{p}{\gamma} + \frac{V^2}{2g} + z\right)_{\text{out}} = \left(\frac{p}{\gamma} + \frac{V^2}{2g} + z\right)_{\text{in}} + h_s - h_L$$

Miscellaneous:

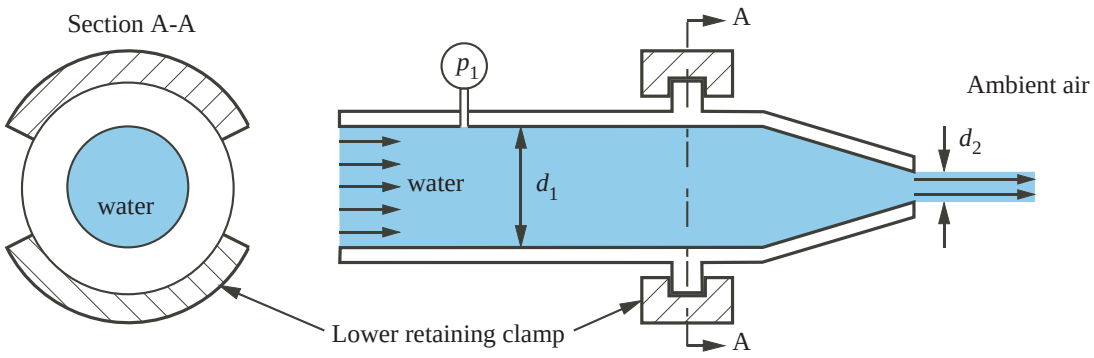
$$\frac{D(\ )}{Dt} = \frac{\partial(\ )}{\partial t} + u\frac{\partial(\ )}{\partial x} + v\frac{\partial(\ )}{\partial y} + w\frac{\partial(\ )}{\partial z}$$

Properties of Volumes:

Sphere: $V = \dfrac{\pi D^3}{6}, \quad A = \pi D^2$

Questions 1–4 refer to the same schematic.

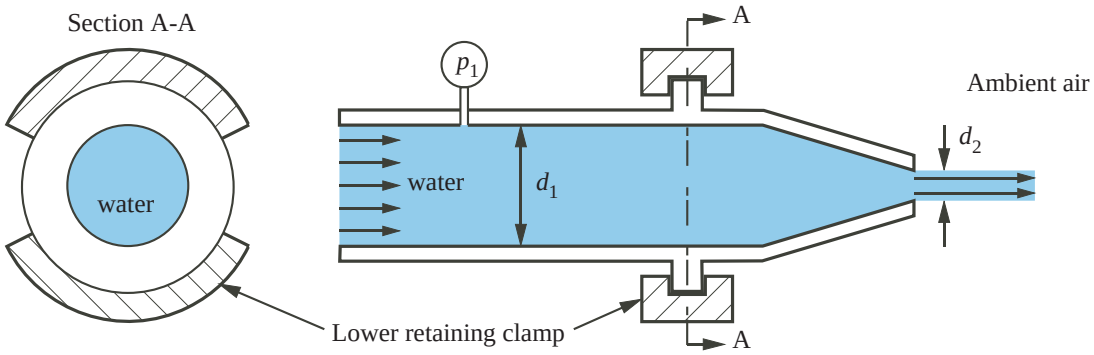
Water from a pipeline flows through the axisymmetric nozzle depicted in the sketch. The jet of water leaving the nozzle flows into the ambient air. A ridge around the external circumpherence of the nozzle provides a surface for attaching two annular retaining clamps that hold the nozzle in place.



1. **[15 points]** 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 and derive a single formula for the horizontal force on the retaining ring. The formula should be of the form $F = \ldots$ where all terms on the right hand side are known.

2. **[5 points]** Assume that $p_1 > 0$ (gage) and $d_1 > d_2$ (as shown). Under what conditions would the nozzle move to the right if the clamps were suddenly removed?

Questions 1–4 refer to the same schematic.



3. [**15 points**] The volumetric flow rate Q, the dimensions d_1 and d_2, and the reading on the pressure gage p_1 are known. Derive a formula for the head loss for the flow through the nozzle. The head loss should be of the form $h_L = \ldots$ where all terms on the right hand side are known.

4. [**5 points**] Is there a value of p_1 that would make the head loss zero? If so, what is that value?