AER210 VECTOR CALCULUS and FLUID MECHANICS

Quiz 4

Duration: 70 minutes

26 November 2012

Closed Book, no aid sheets

Non-programmable calculators allowed

Instructor: Alis Ekmekci

Family Name: _____

Given Name: _____

Student #: _____

TA Name/Tutorial #: _____

FOR MARKER USE ONLY		
Question	Marks	Earned
1	5	
2	16	
3	10	
4	10	
5	11	
TOTAL	52	/50

Name: _____

1) Circle the true statement in the following:

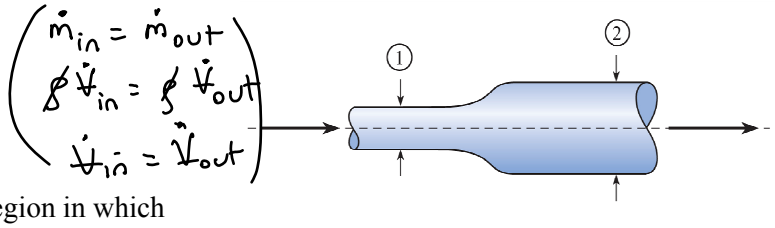
- [**1 mark**] The law of conservation of mass for a system requires that the mass of the system is

a. constant b. zero

- [**1 mark**] Air is flowing from a ventilation duct (cross section 1) as shown in the figure, and is expanding to be released into a room at cross-section 2. The area at cross section 2, A_2, is 3 times A_1. Assume that the density is constant. The relation between the volume flow rates $\dot{V}_1$ and $\dot{V}_2$ is:

a. $\dot{V}_2 = (1/3)\dot{V}_1$
b. $\dot{V}_2 = \dot{V}_1$
c. $\dot{V}_2 = 3\dot{V}_1$
d. $\dot{V}_2 = 9\dot{V}_1$

$\dot{m}_{in} = \dot{m}_{out}$
$\rho \dot{V}_{in} = \rho \dot{V}_{out}$
$\dot{V}_{in} = \dot{V}_{out}$



- [**1 mark**] A boundary layer is a region in which

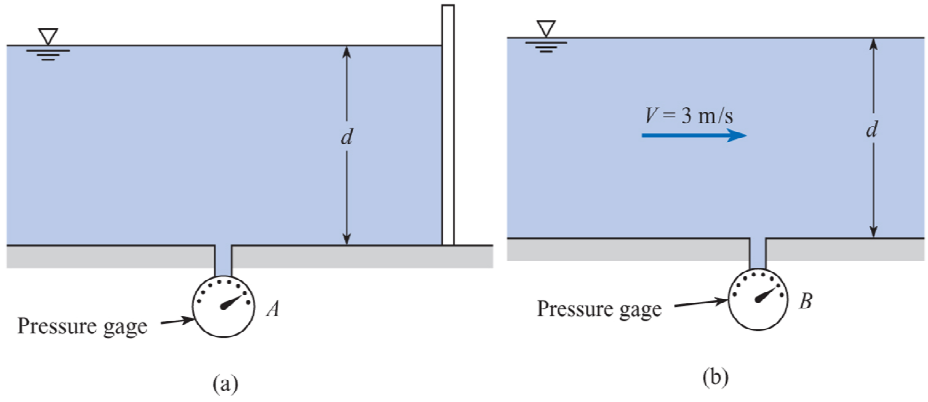
a. viscous forces can be neglected
b. viscous forces cannot be neglected
c. Bernoulli equation applies
d. Pressure is always equal to the atmospheric pressure

- [**1 mark**] Indicate which one is not an assumption, used in the derivation of Bernoulli equation.

a. compressible flow
b. steady flow
c. frictionless flow
d. flow along a streamline

- [**1 mark**] Water in a flume is shown for two conditions. In (a) the water is hydrostatic, and in (b) the water flows with 3 m/s. If the depth d is the same for each case, which one is true:

a. Pressure gage A reads greater than gage B.
b. Pressure gage A reads less than gage B.
c. Pressure gages A and B read identical pressure values.



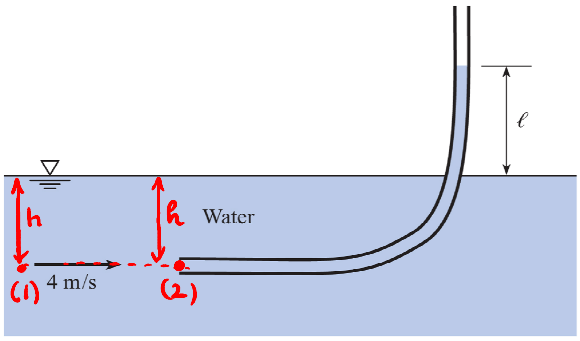
Name: _____

2) a) [**3 marks**] Bernoulli equation is given below. Indicate the meaning of each term on the left hand side of this equation:

$$\frac{p}{\rho} + \frac{V^2}{2} + gz = \text{constant}$$

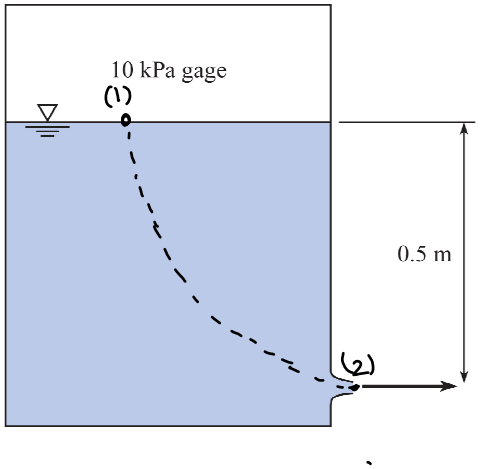
b) [**2 marks**] Is the pattern produced by smoke rising from a chimney on a windy day analogous to a pathline or streakline? Explain.

c) [**5 marks**] A glass tube is inserted into a flowing stream of water with one opening directed upstream and the other end vertical. If the water velocity is 4 m/s, how high will the water rise in the vertical leg relative to the level of the water surface of the stream? (Gravitational acceleration is g = 10 m/s^2)



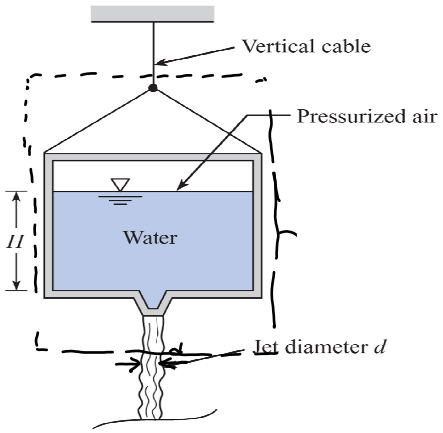
d) [**3 marks**] Velocity field is given by $\vec{\mathbf{V}} = (0.5+x)\vec{\boldsymbol{\imath}} + (2-2y)\vec{\boldsymbol{\jmath}}$. Determine the location of the stagnation points in the flow field.

e) [**3 marks**] A gage pressure of 10 kPa is applied to the surface of water in an enclosed tank. The distance from the water surface to the outlet is 0.5 m. The density of the water is $\rho = 1000$ kg/m^3 and the gravitational acceleration $g = 10$ m/s^2. Find the velocity (m/s) of water at the outlet. Assume that the speed of the water surface is much less than the water speed at the outlet.



Name: _____

3) [**10 marks**] A tank of water with a total weight of 200 N (water plus the container) is suspended by a vertical cable. Pressurized air drives a water jet (d = 12 mm) out the bottom of the tank such that the tension in the vertical cable is 10 N. If H = 425 mm, find the required gage pressure of the air. Assume that Bernoulli equation is applicable to the flow and the tank is large (therefore, the speed of the water surface is much less than the water speed at the outlet). Density of the water is $\rho = 1000\ kg/m^3$ and the gravitational acceleration is $g = 10\ m/s^2$.

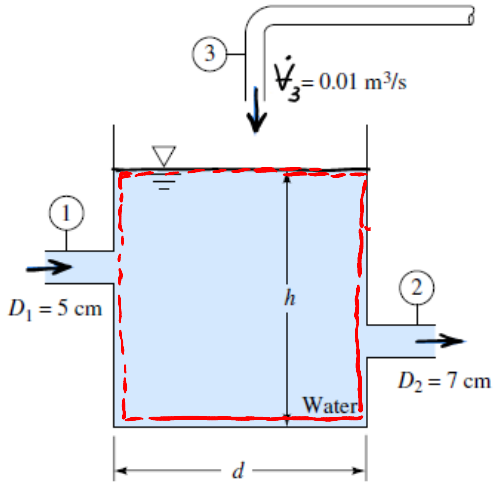


<u>Hint:</u> First, apply the momentum equation to a suitable control volume to find the exit velocity using the information of cable tension and total weight; then, apply Bernoulli equation between appropriate points to find the pressure in the air.

Name: _____

4) The general integral form of the continuity equation, applicable to a control volume is given as:

The cylindrical tank shown in the figure below contains water. The tank is being filled through sections 1 and 3, while being emptied through section 2. Assume that all sections (section 1, 2 and 3) have circular cross-sections.



a) [**6 marks**] Derive an analytic expression for the water-level change *dh/dt* in terms of volume flow rates ($\dot{\forall}_1$, $\dot{\forall}_2$, $\dot{\forall}_3$) and the tank diameter d.

Hint: First, select an appropriate control volume, and then apply the integral form of the continuity equation to this control volume.

b) [**4 marks**] If the water level h is constant, the velocity at section 1 is $V_1 = 3$ m/s and the volume flow rate at section 3 is $\dot{\forall}_3 = 0.01$ m^3/s, determine the exit velocity V_2.

EXTRA PAGE

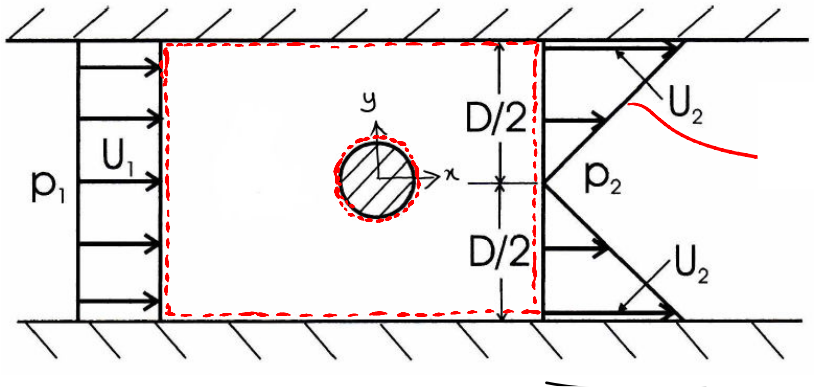
Name: _____

5) A cylinder is held in a two-dimensional duct of constant width w and height D. As a result, the downstream velocity distribution becomes as shown below. The density ρ is constant and the flow is steady.

a) [**4 marks**] Find U_2 in terms of U_1.

b) [**7 marks**] Find the horizontal force (that is the drag force) exerted by the fluid on the cylinder in terms of ρ, U_1, w and D. Neglect frictional effects on the duct surfaces and assume that the pressure at the upstream and downstream are approximately equal ($p_1 \cong p_2$).

Hint: select a control volume between sections 1 and 2, particularly excluding the cylinder.



EXTRA PAGE