AER210 VECTOR CALCULUS AND FLUID MECHANICS

Fluid Mechanics Part, Quiz # 4

28 November 2011   9:15-10:15

Closed book, no aid sheets

Non-programmable calculators allowed
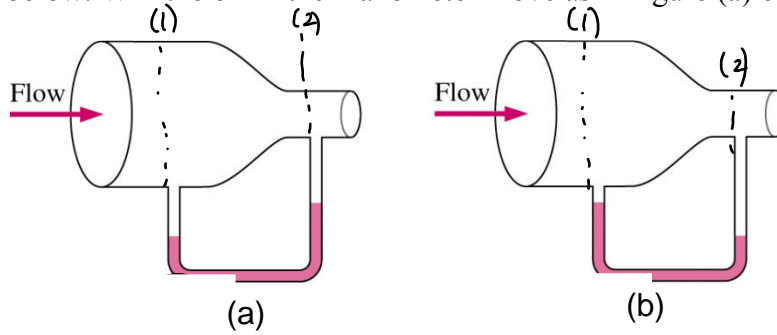
Instructor: Alis Ekmekci

Family Name: ___Alis_____

Given Name: ___Ekmekci_____

Student #: _____

TA Name/Tutorial #: _____

FOR MARKER USE ONLY		
Question	Marks	Earned
1	9	
2	9	
3	45	
4	12	
5	8	
6	10	
TOTAL	~~52~~ 53	/50

1) a) A glass manometer with oil as the working fluid is connected to an air duct as shown below. Will the oil in the manometer move as in figure (a) or figure (b)? Explain. [**2 marks**]

(a)   (b)

b) Velocity field is given by $\vec{V} = u\hat{i}+v\hat{j}$ where $u = x+y$ and $v = xy+4$. Determine the location of the stagnation points in the flow field. [**3 marks**]

c) Indicate the four major assumptions, used in the derivation of Benoulli equation. [**4 marks**]

2) a) Using the Reynolds Transport theorem derive the conservation of mass equation for a control volume (in other words, the integral form of the continuity equation). [**4 marks**]

*Hint: Start with the conservation of mass equation for a fluid system. Then use the Reynolds Transport Theorem to convert the conservation of mass equation for a control volume. The Reynolds Transport Theorem for a fluid parameter **B** = **mb** can be written as:*

$$\frac{dB_{sys}}{dt} = \frac{dB_{CV}}{dt} + \dot{B}_{out} - \dot{B}_{in} \quad \text{or} \quad \frac{dB_{sys}}{dt} = \frac{dB_{CV}}{dt} + \oint_{CS} b\rho\vec{V}.\overrightarrow{dA}$$

b) Indicate whether the statement is TRUE or FALSE: [**5 marks**]

_____ A stagnation point occurs where the pressure becomes a minimum.

_____ A Pitot tube works on the principle of converting kinetic energy to potential energy.

_____ If density varies time-independently in a flow field, then the flow is incompressible.

_____ The Reynolds transport theorem links the Lagrangian and Eulerian approaches.

_____ In gases, an increase in temperature results in an increase in viscosity.

3) Incompressible steady flow between parallel plates is shown in the Figure below. In the inlet, between the two plates, the velocity profile is uniform, $u = U_o = 8$ cm/s. In the downstream, the flow develops into the parabolic laminar profile $u = az(z_o - z)$, where a is a constant. If $z_o = 4$ cm, what is the value of the maximum speed (u_{max}) in cm/s? [**5 marks**]

Note: You can take the plate width into the paper as w.

$z = z_0$

$U_0 = 8 cm/s$

u_{max}

$z = 0$
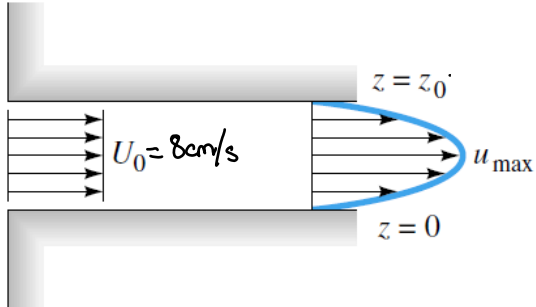
4) A nozzle with $D_2 = 0.15$-m diameter is bolted with six bolts to a pipe with $D_1 = 0.3$-m diameter. If water discharges from the nozzle into the atmosphere, calculate the tension load in each bolt when the gage-pressure in the pipe is 200 kPa. The pipe-nozzle system is horizontal and the density of the water is $\rho_{water} = 1000$ kg/m^3. [**12 marks**]

Hint: The solution involves application of the continuity principle, the Bernoulli equation and the momentum principle.
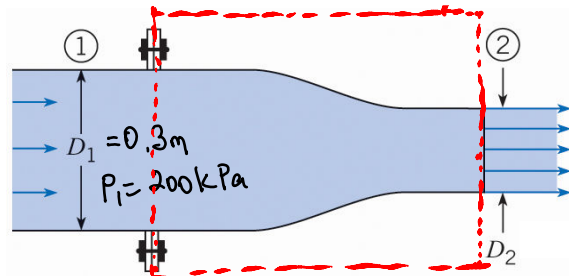
5) Water flows from the **large open** tank as shown in the figure below. If viscous effects are neglected, determine the heights h_1, h_2, and h_3, to which the three jet streams rise. [**8 points**]

Hint: Note that unlike the vertical jets, at the top of the slanted jet the velocity is not zero. In fact, the horizontal component of velocity at the exit of the slanted pipe is equal to the horizontal component of velocity at the highest point of the slanted jet (since the acceleration in the horizontal direction is zero).

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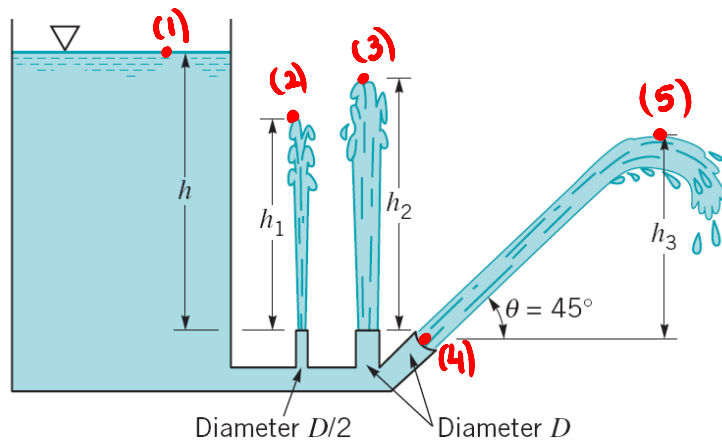
6) A horizontal jet of water that is 6 cm in diameter and has a velocity of 20 m/s (absolute) is deflected by the vane as shown. If the vane is moving at a rate of 7 m/s in the x direction, what components of force are exerted on the vane by the water in the x and y directions? Assume negligible friction between the water and the vane and neglect gravitational effect. (**10 points**)

Hint: In momentum analysis, select both the control volume and the reference frame moving with the vane.