AER210 VECTOR CALCULUS and FLUID MECHANICS

Fluid Mechanics Part - Quiz 3

14 November 2011 9:15 am – 10:15 am

Closed Book, no aid sheets

Non-programmable calculators allowed

Instructor: Alis Ekmekci

Family Name: Ekmekci

Given Name: Alis

Student #: _____

TA Name/Tutorial #: _____

FOR MARKER USE ONLY		
Question	Marks	Earned
1	15	
2	10	
3	10	
4	12	
5	10	
TOTAL	52	/50

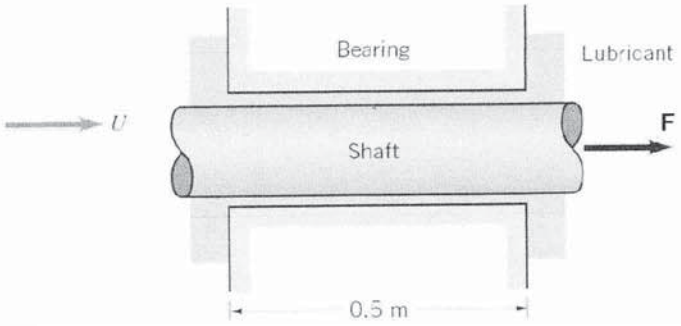
1) a) An unknown liquid seeps into the bottom of an open oil tank. Some measurements indicate that the depth of the unknown liquid is 1.5 m and the depth of the oil floating on top is 5.0 m. The specific weight of the oil $\gamma_{oil} = (\rho g)_{oil} = 8.5$ kN/m^3. A pressure gage connected to the bottom of the tank reads 65 kPa. What is the specific weight γ of the unknown liquid? (**3 points**)

b) In the troposphere, which is the atmosphere from sea level till 11 km from earth's surface, the temperature varies linearly with elevation (z) in the following form:

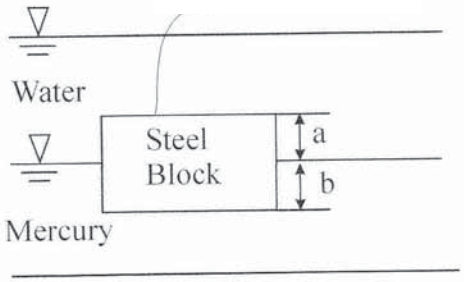
$$T = T_o - \beta z$$

where T_o is the temperature at the sea level ($z=0$) and β is the rate of change of temperature with elevation (z). For standard atmosphere in the troposphere layer $\beta = 0.00650$ K/m. Derive the relationship between pressure and elevation in the troposphere. (**Hint**: the air can be taken as a perfect gas that holds the relationship: $p = \rho RT$ and take the pressure at the sea level ($z = 0$) as p_o) (**4points**)

c) A 25-mm-diameter shaft is pulled through a cylindrical bearing with force F as shown in the figure. The lubricant that fills the 0.3-mm gap between the shaft and bearing is an oil with a viscosity $\mu_{oil} = 0.73$ N.s/m^2. Determine the force F required to pull the shaft at a velocity of 3 m/s. Assume the velocity distribution in the gap is linear. (**4 points**)



c) A uniform block of steel will float at a mercury-water interface as in the figure. The densities of the steel block, water and mercury are as follows: $\rho_{water} = 1000$ kg/m^3, $\rho_{mercury} = 13560$ kg/m^3, $\rho_{block} = 7850$ kg/m^3. What is the ratio of the distances a and b? (**4 points**)



2) a) Define the following terms: streamline, streamtube, streakline. (3 points)

b) Indicate whether the statement is TRUE or FALSE. (7 points)

_____ Boundary layer is a region in which viscous forces can be negligible.

_____ Sreamlines, streaklines and pathlines are identical in a steady flow.

_____ Pascal's law states that pressure at a point acts equally in all directions.

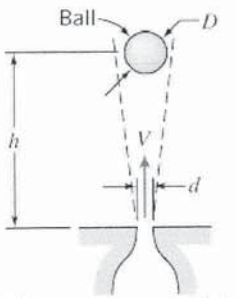
_____ A fluid is defined as a substance which deforms continuously if the shear force that acts on it is large enough.

_____ High viscosity of a fluid enforces the flow towards being laminar.

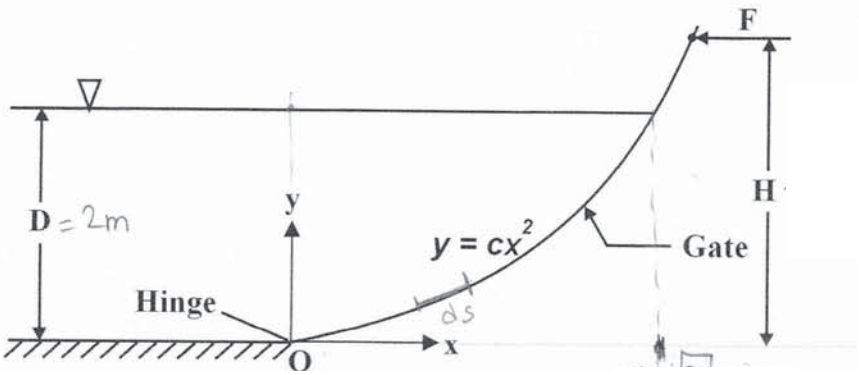
_____ Eulerian method of analyzing flow involves following individual fluid particles as they move about and determining how the fluid properties associated with these particles change as a function of time.

_____ Pressure force is a body force.

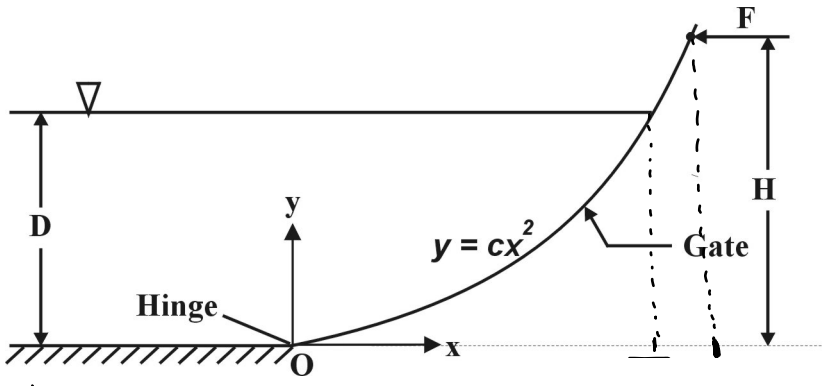
3) The sketch shows an air jet discharging vertically from a nozzle. Experiments show that a ball placed in the jet is suspended in a stable position. The equilibrium height (**h**) of the ball in the jet is found to depend on the diameter of the ball (**D**), nozzle diameter (**d**), the jet speed (**V**), air density (**ρ**), air viscosity (**μ**), and the weight of the ball (**W**). By dimensional analysis, find the dimensionless parameters that you would use to organize data. Express the non-dimensional form of the functional relationship that characterizes this problem. (**10 points**)



4) The parabolic gate $y=cx^2$ has a width of $w = 3$ m and is pivoted at O; $c = ½$ m^{-1}, the water depth $D = 2$ m. A horizontal force **F** is applied $H = 3$ m above the hinge to keep the gate closed. Ignoring the mass of the gate, find the magnitude of the horizontal force **F** required to keep the gate closed. (**12 points**)
Note: density of water is $\rho = 1000$ kg/m^3, gravitational acceleration $g = 10$ m^2/s.



4) The parabolic gate $y=cx^2$ has a width of $w = 3$ m and is pivoted at O; $c = ½$ m^{-1}, the water depth $D = 2$ m. A horizontal force **F** is applied $H = 3$ m above the hinge to keep the gate closed. Ignoring the mass of the gate, find the magnitude of the horizontal force **F** required to keep the gate closed. (**12 points**)
Note: density of water is $\rho = 1000$ kg/m^3, gravitational acceleration $g = 10$ m/s^2.



5) A tank of water 4 m deep received a constant upward acceleration a_z. Determine the gage pressure at the bottom of the tank if $a_z = 5\ m^2/s$. The density of water is $\rho = 1000\ kg/m^3$ and the gravitational acceleration $g = 10\ m^2/s$. (**10 points**)
Hint: $-\vec{\nabla}p - \rho g\hat{k} = \rho\vec{a}$