Elementary Fluid Mechanics

2009 Final Examination

December 14, 2009

1. Fill in the blank. (30 points)

(1) When the absolute pressure drops to the vapor pressure of the liquid, the vaporization or formation of vapor cavities takes place. This phenomenon is called ( ).

(2) The pressure at the zero-velocity point on the nose of any solid object in a flow such as Pitot tube is called a ( ) pressure.

(3) The Bernoulli equation is equivalent to the work-energy equation for ( ) fluid flow.

(4) Flows whose stream function does not satisfy the Laplace equation are ( ) ones.

(5) The concept of impulse-momentum derives from ( ) second law.

(6) The impulse-momentum principle can be employed to predict the fall of the energy line, that is, the energy loss due to a rise in the internal energy of the fluid caused by ( ) dissipation.

(7) For a hydraulic jump to occur, the upstream conditions must be such that ( ) number > 1.

(8) For the small gravity wave, the ( ) depends only on the depth of flow when the length of the wave is large compared to the depth of the water.

(9) The flow of any fluid in cylindrical pipes, the engineer can predict that the flow will be laminar in R < ( ).

(10) Eddy viscosity, ε, was a property of the flow (not the fluid alone) which depended primarily on the structure of the ( ).

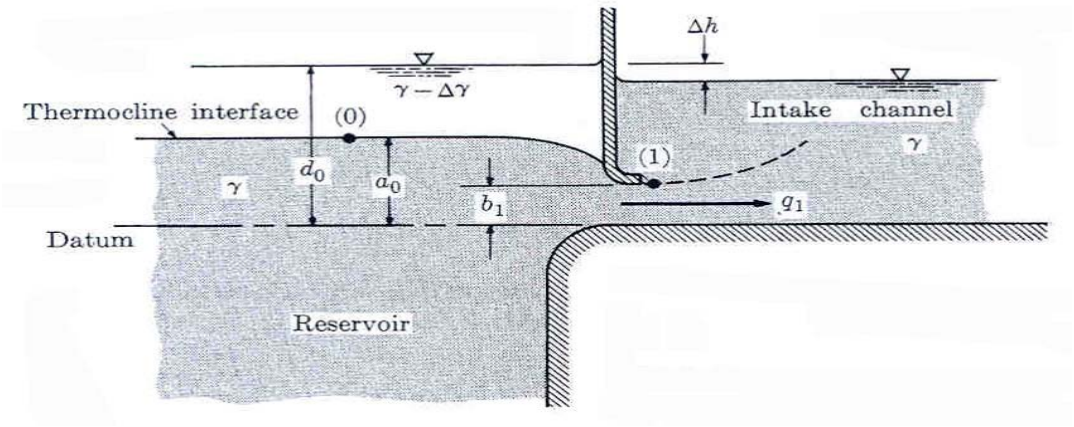
(11) When turbulent flow occurs over smooth solid boundaries, it is always separated from the boundary by a sublayer of ( )-dominated flow.

(12) The wall stress τ_o is the basic resistance stress to be investigated and will produce a force on the solid periphery of passage ( ) the direction of fluid motion.

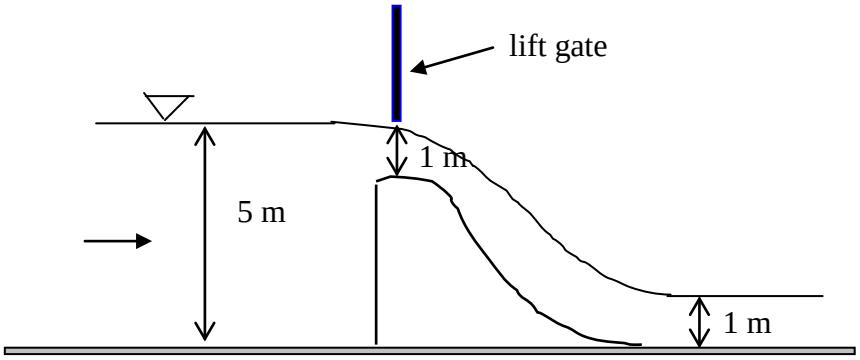
(13) The shearing stresses of laminar and turbulent flow produce velocity distributions characterized by ( ) velocities near boundary surfaces. These deviations from the ( ) velocity distribution of ideal fluid flow.

(14) For constant-density flows, kinematic similarity guarantees complete similarity, while ( ) plus geometric similarity guarantees kinematic similarity.

2. During the summer months, large reservoirs and lakes become thermally stratified, that is, at a certain depth (known as the thermocline) the temperature changes rapidly with depth. This results in a lighter liquid on the top of a heavier one since the specific weight is inversely related to temperature. Figure shows a schematic representation of a stratified reservoir with an intake channel and submerged wall at one side. The colder water is drawn into the intake channel to provide the cooling water for the thermal (nuclear) power plant. Derive the equation for the velocity q_1, which will be considered uniform over the height b_1. Neglect all head losses. (20 points)



3. The two-dimensional overflow structure (dam spillway) produces the flowfield shown below. Calculate the magnitude of the horizontal component of the resultant force the water exerts on the structure when the gate is open. Compare this with the magnitude of the horizontal component of the resultant force the water exerts on the structure when the gate is closed. Assume the water is an ideal fluid. The specific weight of the water is 9,800 N/m^3. (20 points)



4. Air (γ = 12.6 N/m^3) flows through a horizontal 0.3 m by 0.6 m rectangular duct at a rate of 1.19 m^3/s. Find the mean shear stress at the wall of the duct if the pressure drop in a 100 m length is 160 Pa. Compute the power lost per meter of duct length. (15 points)

5. Derive an expression for the flowrate over an overflow structure if this flowrate depends only on size of structure, head on the structure, acceleration due to gravity, and viscosity, density, and surface tension of the liquid flowing. (15 points)