Department of Mechanical Engineering

ME/AA507 Fluid Mechanics Homework #1, due 01-31-19

Problem 1

For a two dimensional flow field given by the velocity components:

$$V_x = \frac{x}{1+t};\ V_y = \frac{y}{1+2t}$$

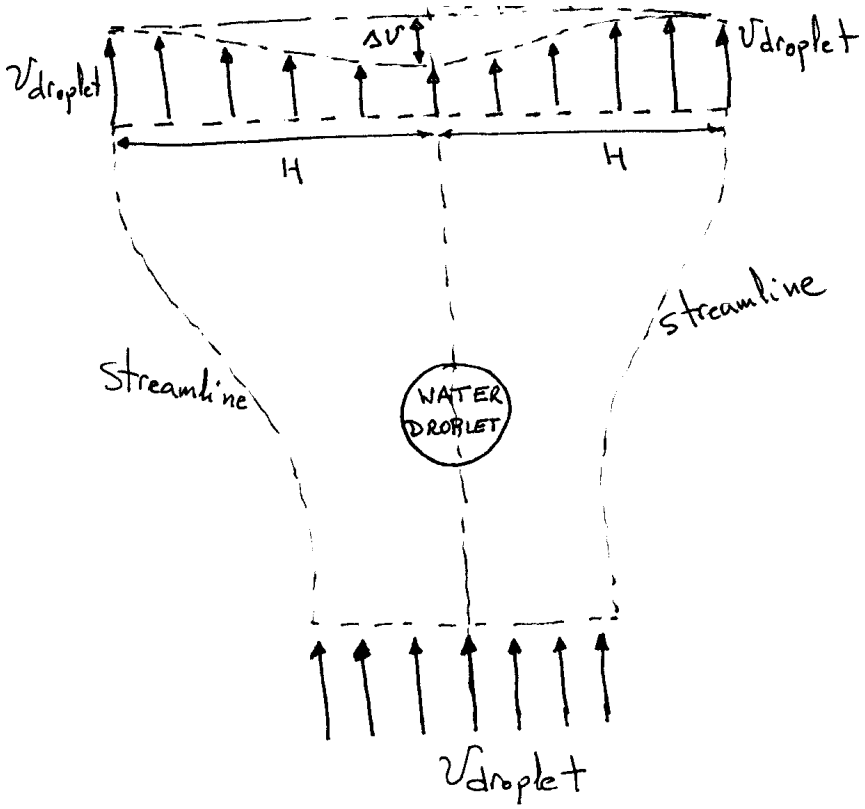
- Calculate the streamlines and the pathlines (trajectories).
- Eliminate time to express the pathlines in implicit form and compare against the streamlines.
- Particularize the previous expressions for the streamlines and pathlines that go through point (x_0, y_0) at time t=0 and t=2. Sketch them on the x-y plane.

Problem 2

To evaluate the terminal velocity of a water droplet in air (velocity at which it falls under gravity at a steady rate) we measure the air velocity behind the droplet as it falls. This velocity can be represented by the expression $V_z(r) = \Delta V(1-(r/H)^2)^2$, where r if the distance to the droplet centerline trajectory and H and ΔV are known quantities.

Calculate the terminal velocity of the droplet and the drag that the air exerts on it.

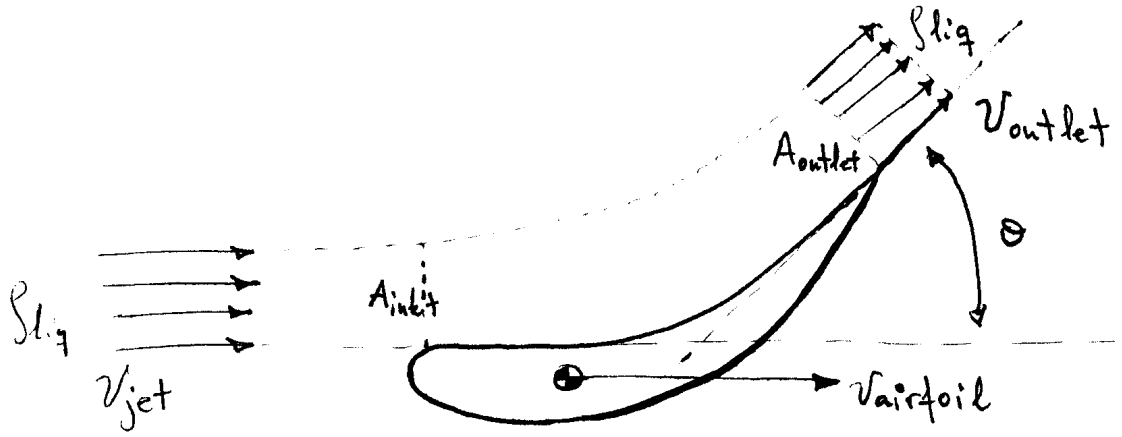
It is useful to study the problem relative to a reference frame fixed to the droplet. In this reference frame the problem, and the appropriate control volume, can be sketched as follows:



Problem 3

A liquid jet impinges on a turbine vane, moving it at a constant velocity ($V_{airfoil}$). Compute the force on the airfoil as a function of the jet and airfoil velocities. Assume that you know the velocity of the jet and the airfoil, the deflection angle θ, the density of the liquid and the inlet and outlet areas.

Apply conservation of Energy to this problem both in a fixed control volume and in one that is moving with the airfoil and try to compare and explain the results.



Problem 4

A jet engine produces thrust on an airplane by burning fuel inside the combustion chamber, a process that can be modeled as an addition of heat $\dot{Q}$ to the system. Obtain a closed system of equations (same number of equations as unknowns) for the Thrust and the conditions at the outlet, velocity, density and internal energy(or enthalpy). You may need to use auxiliary relations for the thermodynamic properties or the constitutive equations for the gas.