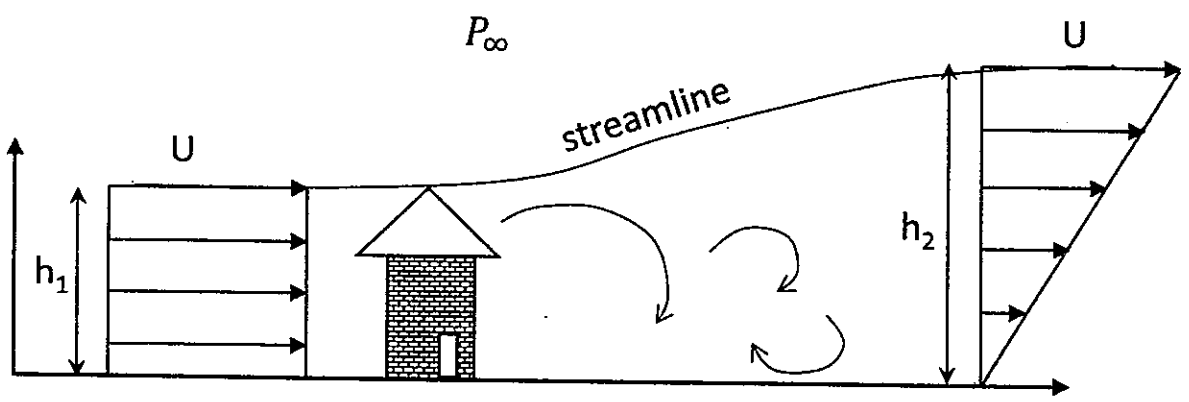
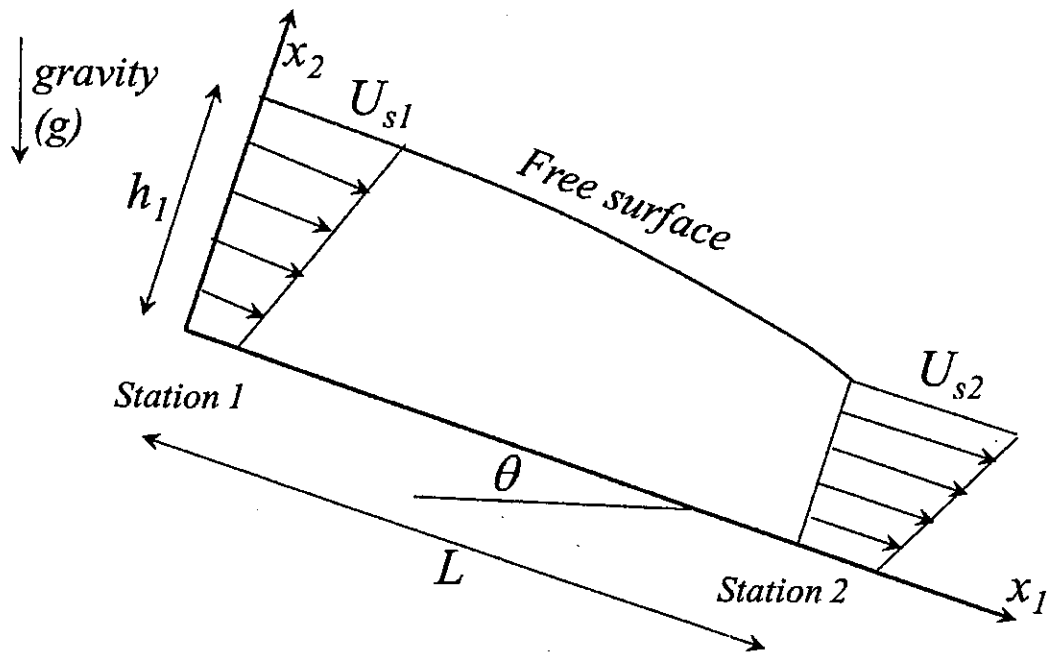
1. Consider the situation depicted below. Wind strikes the side of a simple residential structure and is deflected up over the top of the structure. Assume the following: two-dimensional steady inviscid constant-density flow, uniform upstream velocity profile, linear gradient in the downstream velocity profile (velocity U at the upper boundary and zero velocity at the lower boundary as shown), and constant pressure on the upper boundary of the control volume (streamline).
   (A) (5 pts) Determine h_2 in terms of U and h_1.
   (B) (15 pts) Determine the direction and magnitude of the horizontal force on the house per unit depth into the page in terms of fluid density ρ, the upstream velocity U, and the height of the house h_1.
   (C) (5 pts) How do the velocity profiles change if the flow is viscous?



2. An inclined waterway shown in the figure has a large constant width (in the direction out of the page). The waterway is inclined at an angle relative to the horizontal. At station-1 the water depth is h_1, the flow velocity at the surface ($x_2 = h_1$) is $u_1=U_{s1}$ and the velocity profile is observed to be linear with a constant shear rate $du_1/dx_2 = S_1$. The flow is steady and can be assumed to be inviscid. Station-2 is located L downstream from station-1. Assume that h_1, $h_2 \ll L$.
   (A) (5pts) What is the flow velocity, U_{s2}, at the water surface at station-2?
   Now suppose that the velocity profile at station-2 is also linear.
   (B) (10 pts) What is the shear rate, S_2, at station-2?
   (C) (10 pts) What is the water depth, h_2, at station-2?



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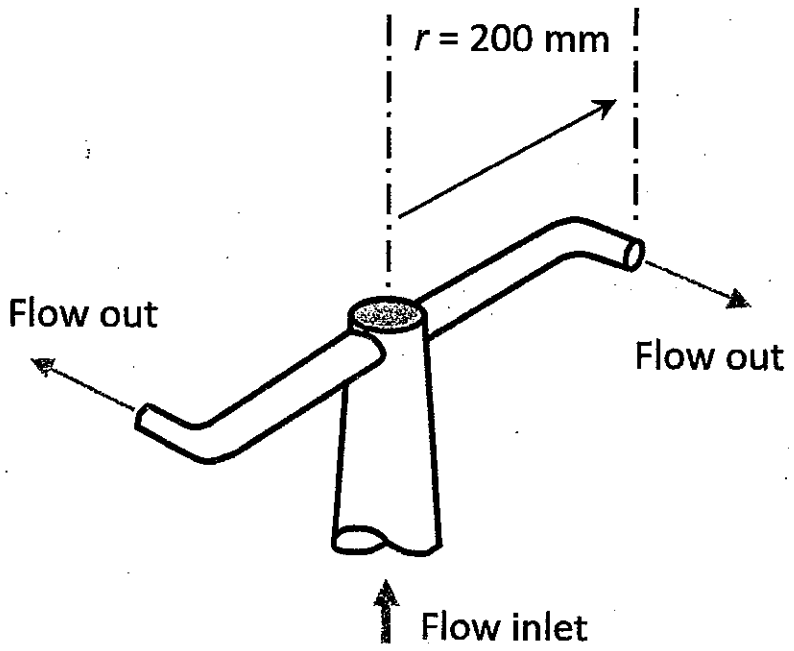
3. As shown in the figure, a rotating lawn sprinkler has water entering through its base at a steady rate of 800 ml/s. The exit outlet of each of the two nozzles is 25 mm^2 and the flow leaving each nozzle is in the tangential direction. The radius from the rotation axis to each nozzle's centerline is 200 mm. Please determine
   (A) (5 pts) the resisting torque required to hold the sprinkler head stationary,
   (B) (10 pts) the absolute velocity of the fluid leaving each nozzle associated with the sprinkler rotating with a constant speed of 500 rev/min, and
   (C) (10 pts) the speed of rotation of the sprinkler head if no resisting torque is applied.



4. Water flows downward at a rate of 3.6 liters/min in a 40-mm-diameter vertical flow pipe. Please determine
   (A) (5 pts) if the flow is laminar or turbulent,
   (B) (5 pts) the pressure drop over a distance of 10 meters,
   (C) (5 pts) the friction head loss per unit length, and
   (D) (10 pts) the shear stress at the pipe wall when $\mu = 1.14 \times 10^{-6}$ $Ns \cdot m^2$.

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