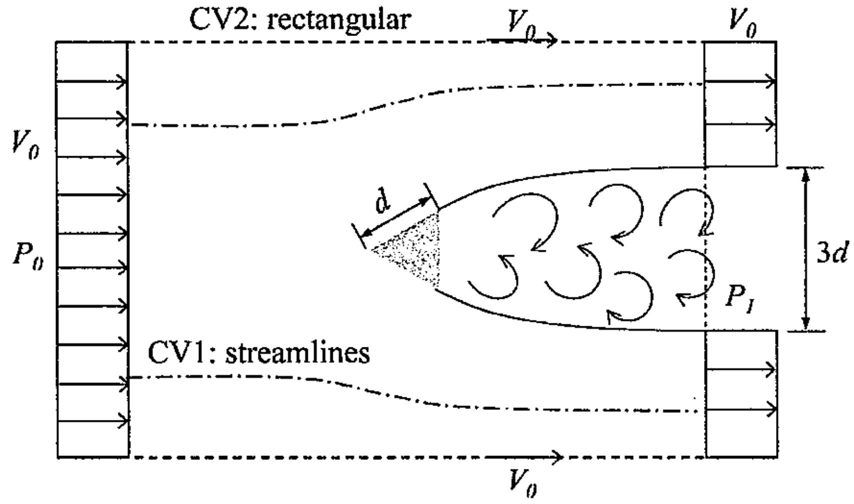
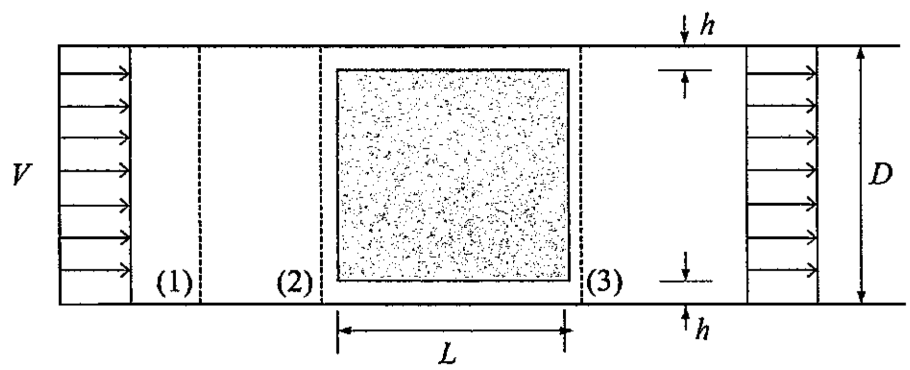
1. In an experiment to determine the aerodynamic force in the high Reynolds number flow, a long regular triangular prism with the triangle edge d was fixed on the wall, immersing in a steady, two-dimensional, unconfined incompressible flow with density ρ. From the measurement at the left boundary of the fixed control volume, CV1 and CV2 shown below, one found the velocity V_0 and pressure P_0. On the right boundary, measurement shows that the height of the wake region is $3d$ and the mean velocity and pressure within the wake region is zero and P_1, respectively. CV1 has sides that are streamline surfaces. CV2 is rectangular. The measured x-component velocity and pressure fields are indicated in the sketch.
(a)(10%) Obtain the drag force exerted on the triangular from the control volume analysis using CV1.
(b)(10%) Write down mass and momentum balance for CV2. Is it the same as what you had in (a)? If not, what is the difference?
(c)(5%) Fine the force to maintain the triangle fixed based on your formulation in (b).



2. As shown in the figure below, an incompressible fluid of density ρ flows into the channel at a uniform velocity V, and the square smaller than the channel width is fixed. The clearance h between the square and the channel wall is small compared to the channel width D.
(a) (5%) Assuming that the fluid flow can be treated as an inviscid flow. determine the pressure difference $P_1 - P_3$ (see the locations defined in the sketch).
(b) (10%) Consider the case when viscous effects are taken into account for the flow in the narrow gap between the square and the pipe wall. Treat this part of the flow as viscous, fully developed. Sketch the velocity profile in the narrow gap between the square and the channel wall. Calculate the velocity profile in the narrow gap between the square and the channel wall.
(c) (10%) Following (b), what is the pressure difference $P_1 - P_3$?



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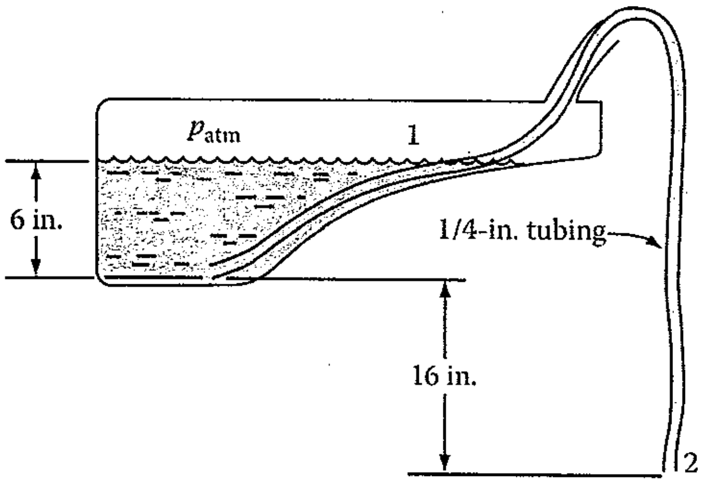
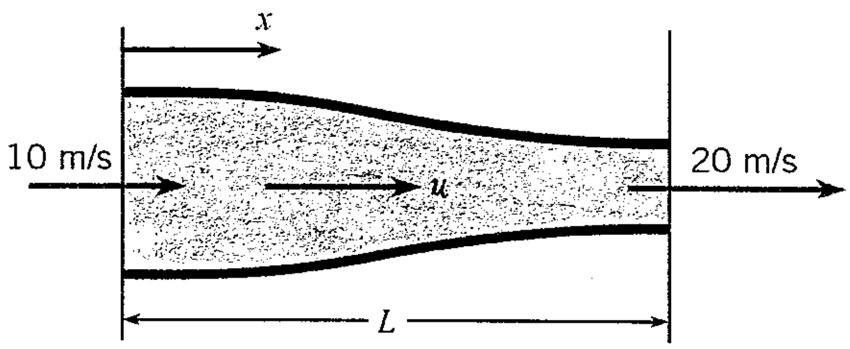
3. (25%) A siphon is set up to remove gasoline from a tank. Quarter-inch-inside diameter flexible tubing is used. Estimate the exit velocity at the instant shown and the volume flow rate.



4. (25%) A nozzle is designed such that the velocity in the nozzle varies as

$$u(x) = \frac{u_0}{1.0 - 0.5x/L}$$

where the velocity u_0 is the entrance velocity and L is the nozzle length. The entrance velocity is 10 m/s, and the length is 0.5 m. The velocity is uniform across each section. Find the acceleration at the station halfway through the nozzle ($x/L = 0.5$).



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