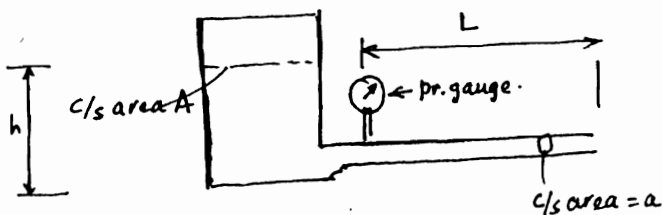


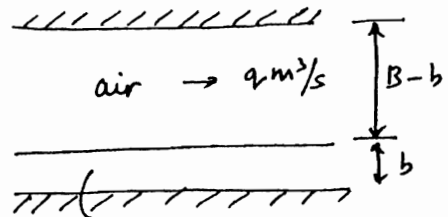
Time 2 Hours. Attempt all questions. Each carries 10 marks. State all assumptions clearly.

- The pressure gauge on the pipe shows that the pressure decreases linearly from p_1 to p_2 over time T . At $t=0$, the flowrate is q_0 . Determine the amount of water that has flown out of the tank in this time. Assume inviscid, incompressible flow, and that the tank has a large cross sectional area, compared to the cross sectional area of pipe, a .
- Consider a very small spherical object of radius a moving through a fluid of viscosity μ and density ρ . The Reynolds number $\frac{\rho V a}{\mu} \approx 0$, where V is the velocity of the sphere. We expect that the parameters for this problem are F, V, a, μ and ρ , where F is the drag force on the sphere.
 - Do you think inertia is important in this problem?
 - Based on (i), is $\rho V^2 a^2$ the correct scaling for F ? If not, what is the appropriate scaling for the drag force? (hint: pressure drag is zero for this flow)
 - Based on (ii), is μ a repeating parameter? Which are the other repeating parameters?
 - Determine the two non dimensional parameters (Π groups). The dependent parameter involves F . What is the independent Π group?
 - Can you determine what is the functional relation between the two Π groups (hint: Since the Reynolds number is nearly zero, it cannot influence the functional form).
- Air is being pumped through a long, wide channel at $q\text{m}^3/\text{s}$. The height of the channel is $B\text{m}$. Water is present at the bottom of the channel to a height b . Calculate the flow rate of water, assuming fully developed flow in both air and water.
- Estimate the power required to drive a raft with floor area of 4m by 4m in still water at 18kmph . The following is known. $\rho_{\text{water}}=1000\text{kg}/\text{m}^3$.

Boundary Layer	$\frac{\delta}{x}$	C_f
Laminar	$\frac{5.48}{\sqrt{Re_x}}$	$\frac{0.73}{\sqrt{Re_x}}$
Turbulent	$\frac{0.382}{Re_x^{1/5}}$	$\frac{0.0594}{Re_x^{1/5}}$



Problem 1.



water
Problem 3.