AML2020/APL107/APL106 (2026-2027-I): Quiz-4

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Maximum score is 40. There are 2 questions in total. Time limit is 60 minutes. Clearly write all your assumptions and steps. No marks will be given for correct answers without any steps.

1. Consider low Reynolds number viscous flow of a fluid of viscosity μ and density ρ in a slipper pad bearing shown below. The length of the slot is ℓ, the thickness $h(x)$ varies as $h(x) = h_i + (h_o - h_i)\frac{x}{\ell}$. The width of the slot inside the page is unity. Pressure on both inlet and outlet ends is atmospheric. Consider the origin at the bottom end of the inlet as shown. **(30)**

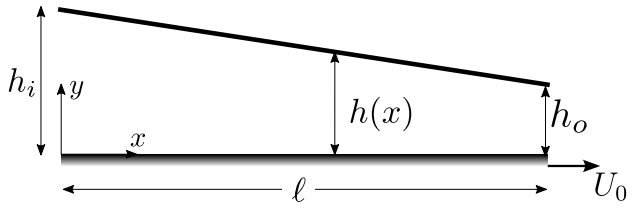


Figure 1: Flow in a slipper-pad bearing

   (a) Non-dimensionalize the Navier-Stokes equations and the continuity equation using suitable scales. Derive the conditions under which the x momentum governing equation reduces to the approximate form, **(10)**

$$\mu \frac{\partial^2 u}{\partial y^2} = \frac{dp}{dx}.$$

   (b) Write down the boundary conditions for u. **(5)**

   (c) Solve the approximate form of the x direction momentum equation derived above and determine the pressure distribution in x. Make a sketch of the pressure distribution vs x. **(10)**

   (d) Find the total vertical force on the lower plate. **(5)**

2. In some speed ranges, vortices are shed from the rear of bluff cylinders placed across a flow. The vortices alternately leave the top and bottom of the cylinder causing an alternating force normal to the freestream velocity. The vortex shedding frequency, f, is thought to depend on ρ, d, V, and μ. Use dimensional analysis to develop a functional relationship for f. Vortex shedding occurs in standard air on two cylinders with a diameter ratio of 2. Determine the velocity ratio for dynamic similarity, and the ratio of vortex shedding frequencies. **(10)**