

APL361 (2025-2026-I): Quiz-4

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October 10, 2025

Maximum score is 40. There are two problems. Time limit is 45 minutes. Clearly write all your assumptions and steps. No marks will be given for correct answers without any steps.

1. Consider the ODE for $\epsilon \ll 1$,

$$\epsilon \frac{d^2 u}{dy^2} + \frac{du}{dy} = a,$$

with $u(0) = 0$ and $u(1) = 1$.

- (a) Compute its exact solution. **(3)**
 - (b) Determine the outer solution. Which boundary condition can the outer solution not satisfy? **(5)**
 - (c) Use $Y = y/\epsilon$ to solve for the inner solution. Combine the outer and inner solution for a uniformly valid solution. **(7)**
2. Flow of speed U_∞ and pressure p_∞ at far upstream enters a duct with a wavy wall at the bottom as shown.

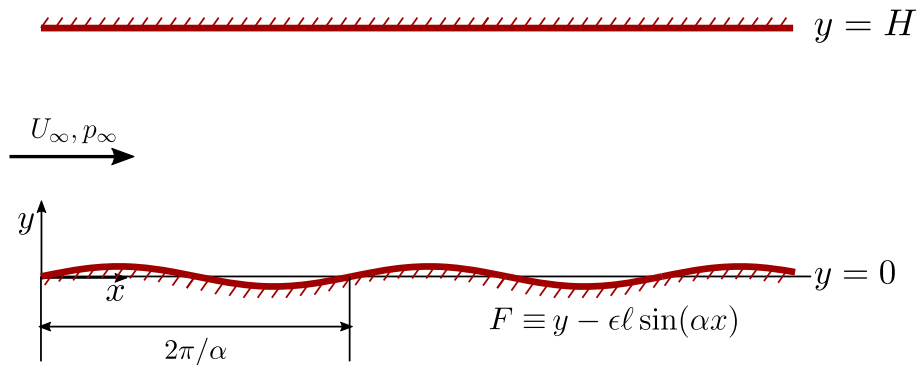


Figure 1: Flow in a duct with a wavy wall.

- (a) State the governing equation and boundary conditions for the flow potential perturbation. **(5)**
- (b) Solve for the leading order flow potential perturbation. **(10)**
- (c) Determine the pressure distribution on the bottom wall. Compute the total force on the bottom wall. **(10)**