تمرین سری هشتم درس جریان لزج

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1. Suppose that $\phi(y) = \phi_R(y) + i\phi_I(y)$ is a complex function, that α is a complex constant and that ω is a real constant.

   (a) Expand the equation

   $$\psi'(x, y, t) = \Re\{\phi(y)e^{i(\alpha x \ \ \omega t)}\}$$

   into an equation involving only real quantities.
   Hint: If you have not already done so, write the right hand side of your equation in the form

   $$A(t)\Phi(y)\cos\{\alpha x - \omega t + \Theta(y)\}$$

   and show that Φ and Θ can be calculated from given values of $\phi_R(y)$ and $\phi_I(y)$.

   (b) Derive an explicit expression for αx, which can be used to plot contours of constant ψ' in the x-y plane, for a given value of t.

2. For two-dimensional inviscid flow, the vorticity may be written as

   $$\frac{\partial \omega}{\partial t} + u\frac{\partial \omega}{\partial x} + v\frac{\partial \omega}{\partial y} = 0$$

   Where

   $$\omega = \frac{\partial v}{\partial x} - \frac{\partial u}{\partial y} = -\nabla^2 \psi$$

   Defining a basic flow (Ψ, U, V, Ω) and disturbances (ψ', u', v', ω'), derive a linearized disturbance equation for this flow. Then assume normal modes as traveling waves:

   $$(\psi', u', v', \omega') = [\hat{\psi}'(y), \hat{u}(y), \hat{v}(y), \hat{\omega}(y)] \exp[i\alpha(x - ct)]$$

   Derive the disturbance equations and, if possible, combine them to obtain a single differential equation for a single disturbance amplitude.

3. For the Howarth freestream velocity $U = U_0 (1 - x/L)$, if $U_0 L/\nu = 10^6$, estimate the point (x/L) where boundary-layer instability first occurs. Assume a low subsonic Mach number.

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