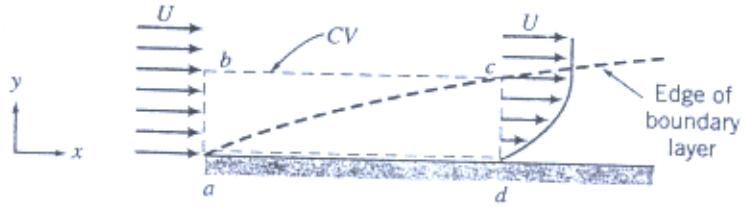
1. A ping-pong ball weighs W (with mass m) and has a diameter of D. It can be supported by an air jet from bottom of the ball to maintain its stationary position. For sea level standard air, (1) derive the steady-state force balance equation of motion of the ball when it is stationary; (2) Obtain the jet velocity V required to maintain the ball in stationary. (Assume the air density at sea level is ρ, static pressure P, and temperature T.) (20%)

2. A boundary layer, as shown, is developed when an airflow ($\rho = 1.24 kg/m^3$) past a flat plate. The flow ahead of the plate is uniform with velocity $\vec{V} = U\hat{i}$, $U = 30 m/s$. The velocity within the boundary layer ($0 \le y \le \delta$) along cd is approximated as $u/U = 2y/\delta - (y/\delta)^2$. At location d, $\delta = 5mm$. The width of the plate is $w = 0.6m$. Calculate the mass flow rate across surface bc of control volume $abcd$.



(20%)

(背面仍有題目,請繼續作答)

3. Consider a steady incompressible flow field. The velocity potential is

$$\phi(x,y,z) = x^2 + y^2 - 2z^2$$

The temperature field is

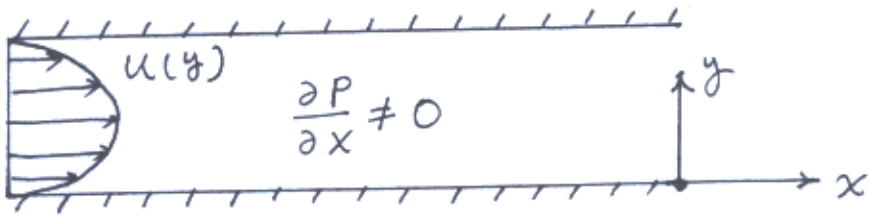
$$T(x,y,z) = x + 3xy + z^2 + 5xyz$$

(a) Please verify whether or not the continuity equation is satisfied.

(b) When a fluid element passes through the point (1,0,1), what is the time rate of change of temperature experienced by this fluid element?

(20%)

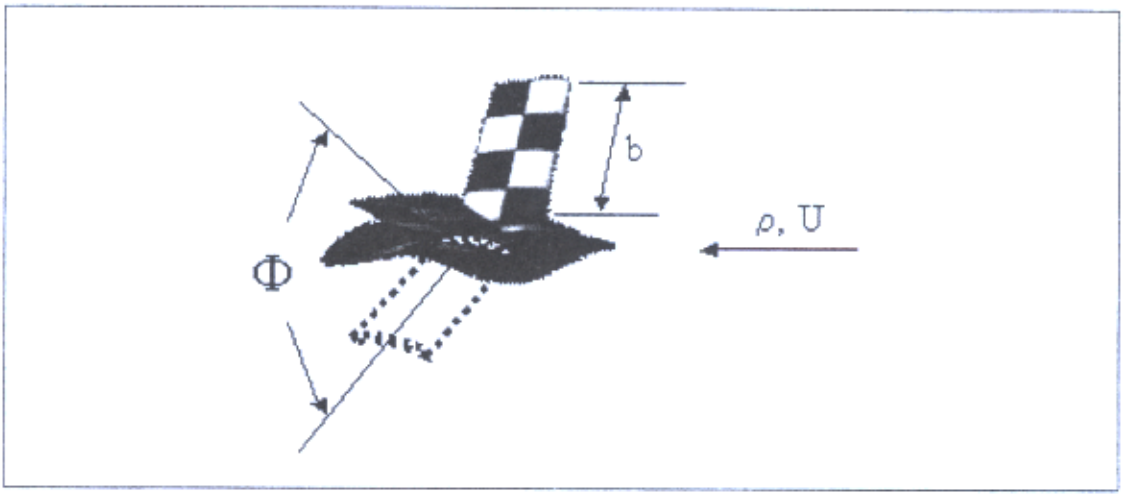
4. Consider a steady, incompressible laminar flow between two flat plates shown in the figure, driven by a pressure gradient along the x direction, namely, $\frac{\partial p}{\partial x} \neq 0$.



The density of the fluid is denoted as ρ. Assume the flow reaches the fully-developed state in the region shown in the figure. (1) Give your explanation of the fully-developed state mentioned; (2) show that the pressure gradient along the x direction is constant in the fully-developed region.

(20%)

5. Consider the problem of computing the thrust force of a wing flapping within air. Let T, U, Φ, f, b, μ and ρ are thrust force, flight speed, stroke angle, flapping frequency, semi-span of the wing, viscosity and density of air respectively. We are interested in determining the thrust force of a flapping wing. Use the dimensionless analysis to find the relevant dimensionless groups associated with the thrust force of a flapping wing



(20%)