國立成功大學
110學年度碩士班招生考試試題

編　號：65

系　所：機械工程學系

科　目：流體力學

日　期：0202

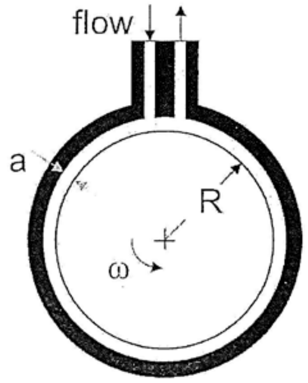
節　次：第 1 節

備　註：可使用計算機

※ 考生請注意：本試題可使用計算機。　請於答案卷(卡)作答，於本試題紙上作答者，不予計分。

1. A viscous shear pump is made from a stationary housing with a close-fitting drum rotating at a speed of ω inside. The clearance, a, is small compared with the radius of the drum, R. Fluid, with density ρ and viscosity μ, is dragged around the annulus by viscous forces. The volumetric flow rate of the flow is Q. Assume that the depth normal to the diagram is b.

Hint: $\nabla = \hat{r}\frac{\partial}{\partial r} + \hat{\theta}\frac{1}{r}\frac{\partial}{\partial \theta} + \hat{z}\frac{\partial}{\partial z}$

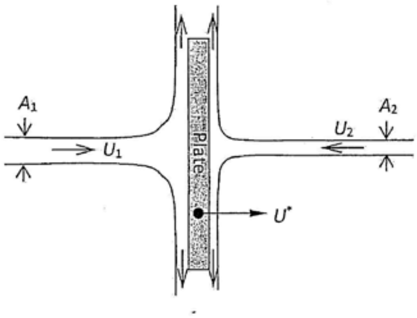


(1) (25%) Neglect the influences of inlet and outlet ports as well as gravity. Simplify the flow in the annulus as flow between coaxial cylinders. Prove that the velocity profile in the annulus is linear. List all assumptions and show the derivation step by step.

(2) (25%) Evaluate the torque applied on the drum (T), pressure differential (Δp), input power (P), and efficiency (η) as functions of volume flow rate Q.

※ 考生請注意：本試題可使用計算機。　請於答案卷(卡)作答，於本試題紙上作答者，不予計分。

2. (25%) Two horizontal water jets impinge on opposite sides of a vertical flat plate:



The jets are uniform far from the plate and have unequal velocities, U_1 and U_2, and cross-sectional areas, A_1 and A_2, as shown. The deflected jets leave the plate with zero component of horizontal velocity relative to the plate. If the plate is free to move horizontally (while remaining vertical) at what steady velocity, U^*, will it travel? Assume that the pressure in the jets far from the plate is atmospheric. Neglect any effects of gravity.

3. (25%) The velocity profile in a turbulent boundary layer of incompressible fluid on a flat plate is to be approximated by the form:

$$u/U = (y/\delta)^{1/7}$$

where U= constant is the velocity outside the boundary layer and δ is the boundary layer thickness. (Disregard the fact that this does not exactly satisfy one of the constraints usually imposed on laminar boundary layer profiles namely that du/dy should tend to zero as y tends to δ). If the wall shear stress, τ_w, for this turbulent profile is assumed to be given by the empirical formula

$$\tau_w = 0.023\rho U^2(\nu/\delta U)^{1/4}$$

where ρ and ν are the fluid density and kinematic viscosity, then solve the resulting Karman momentum integral equation to obtain an expression for the thickness of the boundary layer, δ, as a function of distance, x, along the plate. Assume that the layer first becomes turbulent at $x = x_0$ where the thickness is δ_0.
(Do not use $\tau_w = \mu(du/dy)_{y=0}$ which is inappropriate in turbulent boundary layer calculations.)