博士班資格考流力 A，10-7-09

1. The velocity distribution for laminar flow between parallel plates is given by

$$\frac{u}{u_{max}} = 1 - \left(\frac{2y}{h}\right)^2$$

where h is the distance separating the plates and the origin is placed midway between the plates. Consider flow of water at 15°C with maximum speed of 0.05 m/s and $h = 5$ mm. Calculate the force on a 0.3 m² section of the lower plate and give its direction.

(10%)

$\mu = 1.2 \cdot 10^{-3}$ N·sec/m²

2. Consider the flow field given by $\vec{V} = ax^2y\hat{i} - by\hat{j} + cz^2\hat{k}$, where $a = 1$ m$^{-2}\cdot$s^{-1}, $b = 3$ s^{-1}, and $c = 2$ m$^{-1}\cdot$s^{-1}. Determine (a) the number of dimensions of the flow, (b) if it is a possible incompressible flow, and (c) the acceleration of a fluid particle at point $(x, y, z) = (3, 1, 2)$.

(10%)

3. Standard air enters a 0.3 m diameter duct. The volume flow rate is 2 m³/min. Determine whether the flow is laminar or turbulent. ($\rho = 1.2$ kg/m³) ($\mu = 1.82 \times 10^{-5}$ N·sec/m²)

(10%)

4. Laminar Boundary Layer, Blasius Equation, $2f''' + ff'' = 0$,

$f \equiv \frac{\psi}{\sqrt{\nu x U}}$, $\eta \equiv y\sqrt{\frac{U}{\nu x}}$, $f' = \frac{u}{U}$

由其 Solution (右表)，求

① boundary layer thickness $\equiv \delta$,

② wall shear stress $\equiv \tau_w$,

③ skin friction coefficient $\equiv C_f$,

④ drag $\equiv D$,

⑤ 求 $\bar{C}_f$,

(其中 $\psi \equiv$ stream function, $\nu \equiv$ kinematic viscosity, $U =$ free stream velocity, $u =$ fluid velocity) (20%)

Table The Function $f(\eta)$ for the Laminar Boundary Layer along a Flat Plate at Zero Incidence

$\eta = y\sqrt{\frac{U}{\nu x}}$	f	$f' = \frac{u}{U}$	f''
0	0	0	0.3321
0.5	0.0415	0.1659	0.3309
1.0	0.1656	0.3298	0.3230
1.5	0.3701	0.4868	0.3026
2.0	0.6500	0.6298	0.2668
2.5	0.9963	0.7513	0.2174
3.0	1.3968	0.8460	0.1614
3.5	1.8377	0.9130	0.1078
4.0	2.3057	0.9555	0.0642
4.5	2.7901	0.9795	0.0340
5.0	3.2833	0.9915	0.0159
5.5	3.7806	0.9969	0.0066
6.0	4.2796	0.9990	0.0024
6.5	4.7793	0.9997	0.0008
7.0	5.2792	0.9999	0.0002
7.5	5.7792	1.0000	0.0001
8.0	6.2792	1.0000	0.0000

Fluid Mechanics Qualify Exam (part II) 2009/10

(1) What is the " vortex"? Please write down the expression of velocity potential and stream function for the vortex motion. Also explain the difference between free vortex and forced vortex. (15%)

(1) Please use Navier-Stokes equations (cylindrical coordinates) to derive the expression for the axial velocity for the flow through a horizontal circular tube with radius R . (assume the flow is parallel to the walls so that $v = w = 0$) (15%)

(2) The pressure drop needed to force water through a horizontal 1-in. diameter pipe is 0.6 psi for every 12-ft length of pipe. Determine the shear stress on the pipe wall. Determine the shear stress at distance 0.3 and 0.5 in. away from the pipe wall. (20%)