992 機械系博士班資格考試題目

考試科目	方式	
流體力學	Closed Book,可使用計算機	Part I

1. **GIVEN** The velocity distribution for the flow of a Newtonian fluid between two wide, parallel plates is given by the equation

$$u = \frac{3V}{2}\left[1 - \left(\frac{y}{h}\right)^2\right]$$

where V is the mean velocity. The fluid has a viscosity of $2\ \text{N}\cdot\text{s/m}^2$. Also, $V = 0.6$ m/s and $h = 5$ mm.

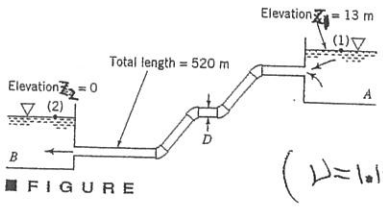
FIND Determine: (a) the shearing stress acting on the bottom wall, and (b) the shearing stress acting on a plane parallel to the walls and passing through the centerline (midplane).

(10%)

2. **GIVEN** Water at 15 °C ($\nu = 1.12 \times 10^{-6}\ \text{m}^2/\text{s}$) is to flow from reservoir A to reservoir B through a pipe of length 520 m and roughness 1.5×10^{-4} m at a rate of $Q = 1\ \text{m}^3/\text{s}$ as shown in Fig. The system contains a sharp-edged entrance and four flanged 45° elbows.

FIND Determine the pipe diameter needed. (Use Colebrook eq.)

$K_{ent} = 0.5$, $K_{elbow} = 0.2$, $K_{exit} = 1$



■ FIGURE

($\nu = 1.12 \cdot 10^{-6}\ \frac{m^2}{s}$)

(15%)

※ Colebrook eq.

$$\frac{1}{\sqrt{f}} = -2.0 \log\left[\frac{\varepsilon/D}{3.7} + \frac{2.51}{Re\sqrt{f}}\right]$$

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. ($\rho = 1.2\ \text{kg/m}^3$) ($\mu = 1.82 \times 10^{-5}\ \frac{N\cdot Sec}{m^2}$)

(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 (有表), 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 平均 $\bar{C}_f$,

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

(15%)

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

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(1) The stream function for a certain incompressible flow field is given by the equation

$$\psi = 2x^2y - \frac{2}{3}y^3$$

Show that the velocity field represented by this stream function satisfies the continuity equation. (15%)

(2) The design of a river model is to be based on Froude number similarity, and a river depth of 3 m is to correspond to a model depth of 100 mm. Under these conditions what is the prototype velocity corresponding to a model velocity of 2 m/s ? (20%)

(3) Please describe how the doublet is formed. Also write down the derivation of the velocity potential and stream function for a doublet. (20%)