Elementary Fluid Mechanics
2009 Final-term Examination

1.(30 point, 2 point each blank)

(1) cavitation

(2) stagnation

(3) ideal

(4) national

(5) Newton's

(6) viscous

(7) Froude

(8) velocity

(9) 2100

(10) turbulence

(11) viscosity

(12) opposing

(13) reduced / uniform (4 point)

(14) dynamic

* miss spell: -1 point / Korean: -1 point

2. (20 point)
Bernoulli Eq between 0 & 1

$$\frac{p_0}{\gamma} + a_0 + 0 = \frac{p_1}{\gamma} + b_1 + \frac{q_1^{\ 2}}{2g}$$ (10 point)

The pressures are obtained from the hydrostatic relationship

$$p_0 = (\gamma - \Delta\gamma)(d_0 - a_0) \quad \& \quad p_1 = \gamma(d_0 - \Delta h - b_1)$$ (5 point)

Substituting the pressure into the Bernoulli Eq

$$\therefore \ \frac{q_1^{\ 2}}{2g} = \Delta h - \frac{\Delta\gamma}{\gamma}(d_0 - a_0)$$

$$\rightarrow \quad \underline{\therefore \ q_1 = \sqrt{2g\left(\Delta h - \frac{\Delta\gamma}{\gamma}(d_0 - a_0)\right)}}$$ (5 point)

3. (20 point)

$$5+\frac{v_1^{\ 2}}{2g}=1+\frac{v_2^{\ 2}}{2g}$$

$$Q=5v_1=v_2$$

$\therefore\ v_1=1.81\text{ (m/sec)},\ v_2=9.04\text{ (m/sec)},\ q=9.04\text{ (m}^2\text{/sec)}$ (2 point)

$\therefore\ F_1=\dfrac{(9.8)(5)^2}{2}=122.5\text{ (kN)},\quad F_2=\dfrac{(9.8)(1)^2}{2}=4.9\text{ (kN)}$ (2 point)

- **Open**

$$\sum F_{ext}=F_1-F_2-F_x=Q\rho(v_2-v_1)=(9.04)(9.04-1.81)=65.33\text{ (kN)}$$

$\therefore\ \underline{F_x=52.27\text{ (kN) = 52,267 (N)}}$ (8 point)

- **Closed**

$$\sum F_{ext}=F_1-F_2-F_x=0$$

$\therefore\ \underline{F_1-F_2=122.5-4.9=117.6\text{ (kN)}}$ (8 point)

4. (15 point)

- **Mean Shear Stress**

The pressure drop p can be written in terms of head loss

$h_{L1-2}=\dfrac{\Delta p}{\gamma}=\dfrac{\tau_0(l_2-l_1)}{\gamma R_h}$ (2 point)

Hydraulic Radius : $R_h=\dfrac{(0.6\times0.3)}{2(0.6+0.3)}=0.1\text{ (m)}$ (1 point)

$$h_{L1-2}=\frac{160}{\gamma}=\frac{\tau_0(100)}{\gamma(0.1)}$$

$\underline{\therefore\tau_0=0.16\text{ (pa)}}$ (5 point)

- **Power lost per length**

$$Power = \gamma h_L Q$$ (2 point)

$$\therefore \frac{Power}{length} = \frac{\gamma h_L Q}{L} = \frac{(160)(1.19)}{100} = 1.904 \text{ (W/m)}$$ (5 point)

5. (25 point)

$$f(Q, l, h, g_n, \mu, \rho, \sigma) = 0$$

1. Q, h, ρ will not combine, $k = m = 3$
2. $n = 7$, $n - k = 4$

$$\pi_1 = f_1(Q, h, \rho, \mu) \qquad \pi_2 = f_2(Q, h, \rho, g_n)$$

$$\pi_3 = f_3(Q, h, \rho, l) \qquad \pi_4 = f_4(Q, h, \rho, \sigma)$$ (2 point)

1) $\pi_1: \frac{M^0 L^0}{t^0} = \left(\frac{L^3}{t}\right)^a (L)^b \left(\frac{M}{L^3}\right)^c \left(\frac{M}{Lt}\right)^d \rightarrow \pi_1 = \frac{Q\rho}{h\mu}$ (2 point)

2) $\pi_2: \frac{M^0 L^0}{t^0} = \left(\frac{L^3}{t}\right)^a (L)^b \left(\frac{M}{L^3}\right)^c \left(\frac{L}{t^2}\right)^d \rightarrow \pi_2 = \frac{Q}{g_n^{1/2} h^{5/2}}$ (2 point)

3) $\pi_3: \frac{M^0 L^0}{t^0} = \left(\frac{L^3}{t}\right)^a (L)^b \left(\frac{M}{L^3}\right)^c (L)^d \rightarrow \pi_3 = \frac{l}{h}$ (2point)

4) $\pi_4: \frac{M^0 L^0}{t^0} = \left(\frac{L^3}{t}\right)^a (L)^b \left(\frac{M}{L^3}\right)^c \left(\frac{M}{t^2}\right)^d \rightarrow \pi_4 = \frac{\rho Q^2}{\sigma h^3}$ (2 point)

$$\therefore \frac{Q}{g_n^{1/2} h^{5/2}} = f\left(\frac{\rho g_n^{1/2} h^{3/2}}{\mu}, \frac{l}{h}, \frac{\rho g_n h^2}{\sigma}\right)$$ (5 point)

* 기타: miss unit (-2 point), calculation error (-2 point)