Memo No.
Date / /

Homework

7.20

$Q = L^3T^{-1}$ $\mu = FTL^{-2}$ $\rho = FT^2L^{-4}$

$H = L$ $l = L$ $g = LT^{-2}$

$\Pi_1 = QH^a\rho^b g^c$

$= (L^3T^{-1})(L)^a(FT^2L^{-4})^b(LT^{-2})^c$

$$\begin{cases} 3 + a - 4b + c = 0 \\ -1 + 2b - 2c = 0 \\ b = 0 \end{cases} \iff \begin{cases} a = -5/2 \\ b = 0 \\ c = -1/2 \end{cases}$$

$\rightarrow \Pi_1 = QH^{-\frac{5}{2}}\rho^0 g^{-\frac{1}{2}} = Q\sqrt{1/H^5g}$

$\Pi_2 = \mu H^a\rho^b g^c$

$= (FTL^{-2})(L^a)(FT^2L^{-4})^b(LT^{-2})^c$

$$\begin{cases} 1 + b = 0 \\ 1 + 2b - 2c = 0 \\ -2 + a - 4b + c = 0 \end{cases} \iff \begin{cases} a = -3/2 \\ b = -1 \\ c = -1/2 \end{cases}$$

$\rightarrow \Pi_2 = \mu H^{-\frac{3}{2}}\rho^{-1}g^{-\frac{1}{2}} = \mu/\rho\sqrt{1/H^3g}$

$\Pi_3 = \frac{l}{H}$

$\Pi_1 = \Phi(\Pi_2, \Pi_3)$

$$\frac{Q}{\sqrt{H^5g}} = \Phi\left(\frac{l}{H}, \frac{\mu}{\rho\sqrt{1/H^3g}}\right)$$

7.22

$\dot{W} = ML^2T^{-3}$ $\rho = ML^{-3}$ $Q = L^3T^{-1}$

$D = L$ $\mu = ML^{-1}T^{-1}$ $\omega = T^{-1}$

$\Pi_1 = \dot{W}D^a\rho^b\omega^c$

$= (ML^2T^{-3})(L)^a(ML^{-3})^b(T^{-1})^c$

$$\begin{cases} 1 + b = 0 \\ 2 + a - 3b = 0 \\ -3 - c = 0 \end{cases} \iff \begin{cases} a = -5 \\ b = -1 \\ c = -3 \end{cases}$$

$\Pi_2 = \mu . D^a\rho^b\omega^c$

$= (ML^{-1}T^{-1})(L)^a(ML^{-3})^b(T^{-1})^c$

$$\begin{cases} 1 + b = 0 \\ -1 + a - 3b = 0 \\ -1 - c = 0 \end{cases} \iff \begin{cases} a = -2 \\ b = -1 \\ c = -1 \end{cases}$$

Memo No.
Date / /

$$\rightarrow \pi_2 = \mu D^{-2} \rho^{-1} \omega^{-1} = \frac{\mu}{D^2 \rho \omega}$$

$$\pi_3 = \frac{Q}{D^3 \omega} \qquad \frac{\dot{W}}{D^5 \rho \omega^3} = \phi\left(\frac{\mu}{D^2 \rho \omega}, \frac{Q}{D^3 \omega}\right)$$

8.3 ⊕ $\mu = 1000 \mu_{H_2O}$

$$Re = \frac{\rho D V}{\mu} = \frac{\rho V D}{1000 \mu_{H_2O}} = \frac{(1{,}6 \frac{slugs}{ft^2})(4 \frac{ft}{s})(\frac{2}{12} ft)}{1000 \times (2{,}34 \times 10^{-5} \frac{lb.s}{ft^2})}$$

$Re = 45{,}6 < 2100$

→ the paint exit as laminar flow in blue & yellow streams

⊕ $\mu = 10 \mu_{H_2O}$

$$Re = \frac{(1{,}6 \frac{slugs}{ft^2})(4 \frac{ft}{s})(\frac{2}{12} ft)}{10 \times (2{,}34 \times 10^{-5} \frac{lb.s}{ft^2})} = 4560 > 4000$$

→ the paint exit as turbulent flow in green

8.9 $u(r) = 2(1 - \frac{r^2}{R^2})$

Maximum V occurs at the centerline of pipe $(r=0)$

$u(0) = 2(1 - \frac{0^2}{R^2}) = 2 \, m/s$

Average V:

$$V_{avr} = \frac{V_{max}}{2} = \frac{2}{2} = 1 \, m/s$$

Volume flow rate

$$Q = V_{avr} . A = (1 \, m/s)(\frac{\pi}{4} . \frac{4}{100} \, m^2) = 1{,}26 \times 10^{-3} \, m^3/s$$

8.19. $h_L = \frac{4 L \tau}{\gamma D}$

thus, $\tau = \frac{\rho V^2 f}{8}$; $\gamma = \rho g$

$$\rightarrow h_L = f\left(\frac{L}{D}\right)\left(\frac{V^2}{2g}\right)$$

$$\rightarrow 6{,}4 ft = \left(\frac{64}{1500}\right)\left(\frac{20}{0{,}1/12} ft\right)\left(V^2/2(32{,}2 ft/s^2)\right)$$

$\rightarrow V = 2{,}01 \, ft/s$