2011.

ESO 212 QUIZ 2 SOLUTION KEY PAPER A.

(1). Relevant variables : F, μ, V, R. $= 4$.

# of fundamental dimensions $= 3$. $\Rightarrow$ only one group

$[F]$: MLT^{-2}

$[\mu]$: $ML^{-1}T^{-1}$

$[V]$: LT^{-1}

$[R]$: L

$$[\mu] = \frac{M}{LT}$$

$L \Rightarrow R$

$T \Rightarrow R/V$

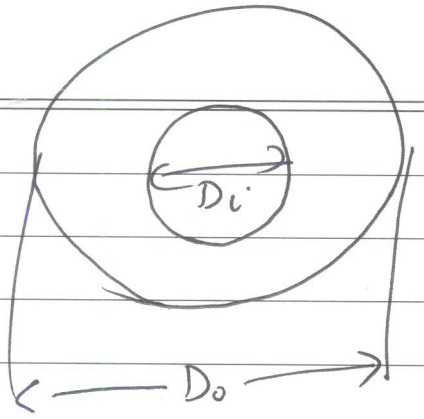
$M \Rightarrow \mu \cdot R \cdot \frac{R}{V}$

$$\frac{F}{\mu R \cdot \frac{R}{V} \; R \; \frac{V^2}{R^2}} \Rightarrow \frac{F}{\mu RV}$$ is the non-dimensional group.

Correct Ans : (C)

$$D_h = \frac{4 \times \text{C.S.A}}{\text{Wetted perimeter}}$$

2.



$$= \frac{4 \times \frac{\pi}{4}(D_o^2 - D_i^2)}{\pi(D_o + D_i)}$$

$$D_h = (D_o - D_i)$$

if $D_o = 2D_i$

$$D_h = 2D_i - D_i$$

$$= D_i$$

Correct Ans: (C)

3. In the fully-turbulent regime, f = const.

$$\frac{\Delta P}{\frac{L}{D} \rho V^2} = \text{Const.}$$

$$V = \frac{Q}{A}$$

$$V^2 = \frac{Q^2}{A^2}$$

$$= \text{Const.}$$

$$\frac{\Delta P}{\frac{L}{D} \rho \frac{Q^2 16}{\pi^2 D^4}}$$

$$= \frac{Q^2 16}{\pi^2 D^4}$$

if $\Delta P, L, \rho$ = Const

$$\Rightarrow \frac{Q^2}{D^5} = \text{Const} \Rightarrow \frac{Q_2}{Q_1} = \left(\frac{D_2}{D_1}\right)^{5/2}$$

$D_2 = 2D_1$

$$Q_2 = Q_1 (2)^{5/2} = Q_1 \sqrt{32}$$

Correct Ans: (A)

(4.) Relevant non-dim. groups:

$$Re = \frac{\rho V D}{\mu}, \qquad \frac{\Delta P}{\rho V^2}$$

$\rho_m = \rho_p$

$\mu_m = \mu_p$

$$\frac{\rho_m V_m D_m}{\mu_m} = \frac{\rho_p V_p D_p}{\mu_p}$$

$$\Rightarrow \frac{V_m}{V_p} = \frac{D_p}{D_m}$$

(or)

$$\frac{\frac{Q_m}{D_m^2}}{\frac{Q_p}{D_p^2}} = \frac{D_p}{D_m}$$

$$\Rightarrow \frac{Q_m}{Q_p} = \frac{D_m}{D_p} = \frac{4}{40} = \frac{1}{5}$$

$$Q_m = \frac{Q_p}{5} = \frac{1.5}{5} = 0.3\ m^3/s$$

$$\frac{\Delta P_m}{\rho V_m^2} = \frac{\Delta P_p}{\rho V_p^2} \Rightarrow \Delta P_m = \Delta P_p \frac{V_m^2}{V_p^2}$$

$$\Delta P_m = 400\ kPa \times 25$$

$$= 10{,}000\ kPa.$$

Correct Ans: (D)

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ESO 212 QUIZ 2 SOLUTION KEY PAPER B

(1) Relevant variables: $\frac{\Delta P}{L}$, μ, R, V.
for fully-developed flow

$\frac{\Delta P/L}{\mu V/R^2}$ is the correct non-dim. group.

Correct Ans. (A).

(2) $D_h = D_o - D_i \Rightarrow D_h = D_o - \frac{3}{4} D_o$

$D_h = \frac{D_o}{4}$

Correct Ans. (D)

(3). $f = \text{const.} \Rightarrow f = \frac{\Delta P}{\frac{1}{D} \rho V^2} = \text{const.}$ $V = Q/A$

$Q \propto D^{5/2} \Rightarrow \frac{Q_2}{Q_1} = \left(\frac{D_2}{D_1}\right)^{5/2}$

$\frac{Q_2}{Q_1} = \left(\frac{D_1}{2 D_1}\right)^{5/2}$

$Q_2 = Q_1 \frac{1}{\sqrt{32}}$.

Correct Ans: (B)

(4). $\frac{\rho V D}{\mu}$, $\frac{\Delta P}{\rho V^2}$ are the two relevant groups.

$$\frac{\rho_m V_m D_m}{\mu_m} = \frac{\rho_p V_p D_p}{\mu_p}$$

$$V = Q/A$$

$$= \frac{Q}{A}$$

$$V = \frac{Q}{\pi D^2/4}$$

$$\frac{Q_m}{Q_p} = \frac{D_m}{D_p} = \frac{4}{40} = \frac{1}{10}$$

$$Q_m = 1.5 \times \frac{1}{10} = 0.15 \ m^3/s$$

$$\frac{\Delta P_m}{\rho V_m^2} = \frac{\Delta P_p}{\rho V_p^2}$$

$$\frac{\Delta P_m}{\Delta P_p} = \frac{V_m^2}{V_p^2}$$

$$= \frac{D_p^2}{D_m^2}$$

Correct Ans. (D)

$$\Delta P_m = \Delta P_p \times \frac{D_p^2}{D_m^2} = 400 \times 100$$

$$= 4 \times 10^4 \ kPa$$

(2)

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