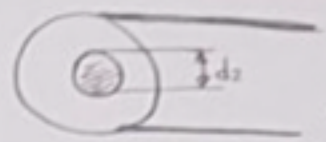
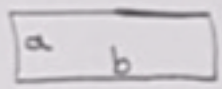
4.1



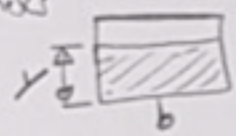
$D_e = 4\left(\frac{\pi}{4} d^2\right)/\pi d = d$ ...... for circular

$D_e = d_1 - d_2$ ...... for annular.

$D_e = 2ab/(a+b)$ ---- for rectangular duct



$D_e = 4(b \cdot y)/(b+2y)$ ---- for open channels



4.2

$Q = 0.015\ m^3/s \quad d = 75\ mm \quad L = 70\ m \quad \mu = 2.5\ mNs/m^2$

$\rho = 1060\ kg/m^3$

roughness $= 6 \times 10^{-5}\ m$

$$Re = \frac{\rho u d}{\mu} = \frac{(1060)(3.395)(0.075)}{2.5 \times 10^{-3}} = 107976.9 \ \text{(turbulent)}$$

$$Q = uA \Longrightarrow 0.015\ m^3/s = u \times \left[\frac{\pi}{4}(0.075)^2\right] \Longrightarrow u = 3.395\ m/s$$

$$\left\{\begin{array}{l} e/d = \frac{6 \times 10^{-5}}{0.075} = 0.0008 \\ Re = 1 \times 10^{5} \end{array}\right\} \xrightarrow[\text{from fig}]{} (J \text{ or } f)$$

$$\therefore \ -\Delta P_{fs} = 8 J_f \left(\frac{L}{d}\right) \frac{\rho u^2}{2}$$

$$\text{or} \ -\Delta P_{fs} = 4 f (L/d)(\rho u^2/2)$$

4.4 $L = 800\,m$ $d = 150\,mm$ $Q = 0.05\,m^3/sec$

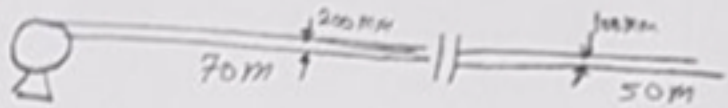
$\Delta P_{fs} = 8\phi\left(\frac{L}{d}\right)\frac{\rho u^2}{2} = \overset{8\phi}{4f}\left(\frac{L}{d}\right)\frac{\rho u^2}{2}$ $e = 1.5\,\mu m$

$Q = uA \rightarrow u \rightarrow Re = \frac{\rho u d}{\mu}$ & $e/d \Rightarrow f$ or 8ϕ

4.5 $\mu = 0.5\,mNs/m^2$ $\rho = 700\,kg/m^3$ $d = 0.15\,m$ $L = 100\,m$

$\Delta P_{fs} = 70\,kN/m^2$

$e = 0.05\,mm$



$\Delta P = 300\,kN/m^2$

Case 1 $\frac{\Delta P}{\rho g} + \cancel{\Delta Z}^{0} + \cancel{\frac{\Delta u^2}{2g}}^{0} - \frac{W_P}{g} + h_F = 0$

$\boxed{\frac{\Delta P}{\rho g} - \frac{W_P}{g} + h_F = 0}$ or $\boxed{\frac{\Delta P}{\rho} - W_P + F}$ $\frac{-\Delta P_{fs}}{\rho g} = F$ head m

$\therefore W_P = \text{—}$

$\phi Re^2 = \left(-\frac{\Delta P_{fs}}{L}\right)\left(\frac{\rho d^3}{4\mu^2}\right) = \text{—}$ & at $\frac{e}{d} \Rightarrow Re \rightarrow u$

$\therefore \boxed{Q = u * A} = \text{—}$

Case 2 at $Q \Rightarrow u_1 = \text{—}$

$u_2 = \text{—}$

$\frac{\Delta P}{\rho} + \frac{\Delta u^2}{2g} - W_P + F_s = 0 \Rightarrow F_s = \text{—}$ $F = \frac{-\Delta P_{fs}}{\rho g} \rightarrow \Delta P_{fs}$

$\therefore \phi Re^2 = \left(-\frac{\Delta P_{fs}}{L}\right)\left(\frac{\rho d^3}{4\mu^2}\right) = \text{—}$

$\therefore Re = \text{—} \rightarrow u \Rightarrow Q$

4.6

$\dot{m} = 3\ kg/sec$ $L = 60\ m$ $d = 25\ mm$ $\rho = 1840\ kg/m^3$

$\mu = 0.025\ \frac{N}{s\,m^2}$

$e = 0.05$

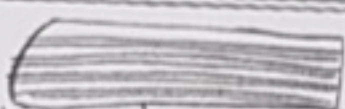
$Q = \dot{m}\,\rho \Longrightarrow Q = U * A$

$\therefore U = \_\_$

$Re = \frac{\rho U d}{\mu} = \_\_$ & $e/d \longrightarrow \phi J_f$

$$\Delta P_{fs} = 8J_f \left(\frac{L}{d}\right)\frac{\rho U^2}{2} = \overset{8J_f}{(4f)}\left(\frac{L}{d_i}\right)\frac{\rho U^2}{2}$$

4.7



$d = 25\ m$ No. ?

$L = 5\ m$ $q = 4\ MW$ cooling

$\Delta P_1 = 2\ kN/m^2$ & smooth tubes

$\mu = 1\ mNs/m^2$

$$\frac{\Delta P}{\rho} + \cancel{\frac{\Delta u^2}{2}}^{0} + \cancel{\Delta z\, g}^{0} - \cancel{nW_s}^{0} + q_{cool} + F_s = 0$$

$$\boxed{F_s = \frac{-\Delta P_{fs}}{\rho} = 8J_f\left(\frac{L}{d}\right)\frac{u^2}{2}}$$

$$\frac{\Delta P}{\rho} + q_{cool} + F_s = 0 \Longrightarrow \frac{2\ kN/m^2 \times 10^3}{1000\ kg/m^3} + (4\times10^6\ W) + F_s = 0$$

$\therefore F_s = \_\_$

Where $F_s = \frac{-\Delta P_{fs}}{\rho} = 8J_f\left(L/d_1\right)\frac{u^2}{2}$ & $J_f = \frac{0.0396}{Re^{0.25}}$

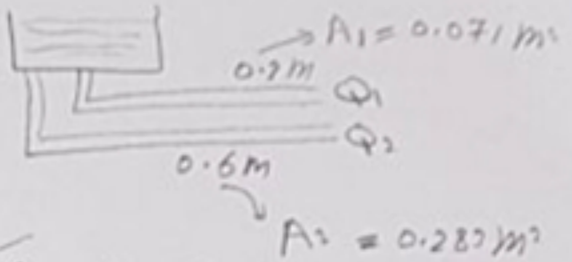
$q = \dot{m}\, c_p\, \Delta T = \dot{m} * \frac{4.2\ kJ}{kg}(20\ C^\circ)$ $Re = \frac{\rho u d}{\mu} = ?$ ← U

$\therefore \dot{m} \Longrightarrow Q \Longrightarrow U \Longrightarrow Re \Longrightarrow J_f$

$\therefore$ from eqn $(F_s) \Longrightarrow L \Longrightarrow No. = \frac{L}{L_1} = \_\_$

4.9 $Q = 1.4\ m^3/s$

$$\frac{A_2}{A_1} = \frac{0.283}{0.071} = 3.99 \quad \boxed{A_2 = 3.99 A_1}$$



case 1

$$Q = \overset{U_1A_1}{\cancel{Q_1}} + \overset{U_2A_2}{\cancel{Q_2}} \Rightarrow 1.4 = U_1A_1 + U_2A_2$$

$$\cancel{1.4 = U_1(0.071) + U_2(0.283)} \Rightarrow \cancel{U_2 = \frac{1.4 - U_1(0.071)}{0.283}}$$

$$= \frac{\pi}{4} d_1^2 \times U_1 + \frac{\pi}{4} d_2^2\, U_2$$

case 2

$$\boxed{A = A_1 + A_2 = \frac{\pi}{4} d_1^2 + \frac{\pi}{4} d_2^2 = 0.071 + 0.283} = 0.354\ m^2$$

$$A = \frac{\pi}{4} d^2 \Longrightarrow d = 0.67\ m$$

رحوع للأول

$$U_1 = \frac{Q_1}{A_2} \quad \& \quad U_2 = \frac{Q_2}{A_2}$$

$$\boxed{Q = Q_1 + Q_2} \Longrightarrow$$

$$Q = U_1A_1 + U_2A_2 \Longrightarrow U_1, \ U_2$$

$$Q = U \times A = 1.4 = U \times \frac{\pi}{4}(0.3)^2$$

$$A = A_1 + A_2$$

$$A_1 = A - A_2$$

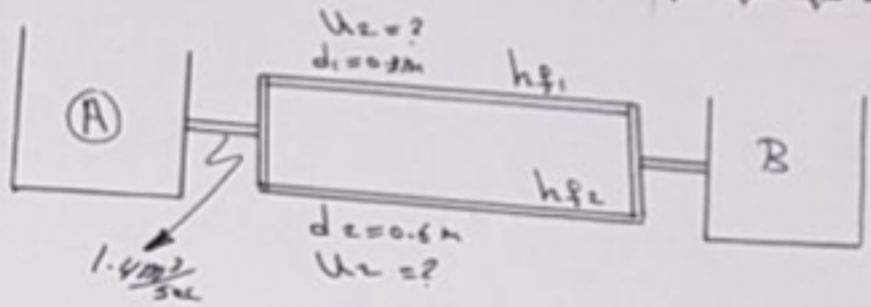
$$Q = UA = U_1A_1 + U_2A_2$$

$$1.4 = U_1(0.071) + \frac{1.4 - U_1(0.071)}{0.283}$$

$$-3.547 = -U_1(0.251 \Rightarrow$$

$$f = (Re)'' \quad \frac{\rho u d}{\mu} =$$

4.9



ΔP = The same
turbulent flow
$\phi = \frac{1}{4} R_e$

I

for parallel $\rightarrow$ $Q_{AB} = Q_1 + Q_2$ & $h_{f_{AB}} = h_{f_1} = h_{f_2}$ & $\Delta P_{AB} = \Delta P_1 = \Delta P_2$

$$\frac{\Delta P}{\rho g} = \frac{P_B - P_A}{\rho g} = h_{f_{AB}} = h_{f_1} = h_{f_2} \quad \text{---- (1)}$$

$$h_{f_1} = 8 J_f \frac{L_1}{d_1}\frac{U_1^2}{2g} = \frac{\Delta P_1}{\rho g}$$
$$h_{f_2} = 8 J_f \frac{L_2}{d_2}\frac{U_2^2}{2g} = \frac{\Delta P_2}{\rho g} \quad \dots \quad \left\{ \& \ J_f = \frac{1}{4} R_e = \frac{1}{4}\frac{\rho u d}{\mu} \right\}$$

$$\therefore \left\{ \begin{array}{l} h_{f_1} = 8\left[\frac{1}{4}\frac{\rho u_1 d_1}{\mu}\right]\frac{L}{d_1}\frac{U_1^2}{2g} = \dots\dots U_1^2 \\ h_{f_2} = 8\left[\frac{1}{4}\frac{\rho u_2 d_2}{\mu}\right]\frac{L}{d_2}\frac{U_2^2}{2g} = \dots\dots U_2^2 \end{array} \right\} \text{---- (2)}$$

* between (1) & (2) $\quad \frac{\Delta P_1}{\rho g} = \frac{\Delta P_2}{\rho g}$ & $h_{f_1} = h_{f_2}$

$$\therefore (\dots)U_1^2 = (\dots)U_2^2 \quad \text{---- (X)}$$
$$\therefore U_2 = (\dots)U_1$$

$$Q_T = Q_1 + Q_2 \longrightarrow 1.4\ m^3/s = U_1 A_1 + U_2 A_2 \Rightarrow U_1 = \dots U_2 \quad (Y)$$

* from eq (X & Y) $\Rightarrow$ $U_1 = \sim$
$U_2 = \sim$

II $\quad \Delta P_{AB} = h_{f_{AB}} = 8 J_f \frac{L}{d}\frac{U^2}{2g} = 8\left[\frac{1}{4}\frac{\rho u d}{\mu}\right]\frac{L}{d_i}\frac{U^2}{2g} = h_{f_1} = h_{f_2}$

$Q = UA = U\frac{\pi}{4}d^2 \quad U \simeq d$

4.10 $\mu = 10\, mNs/m^2$ $\rho = 0.9$ $L = 60\,m$ $d = 100\,mm$

$\Delta P = 13.8\, kN/m^2$

$\mu = 30\, mNs/m^2$ $\rho = 0.95 \longrightarrow$ smooth

$\Delta P = ?$

Case 1

$$\frac{\Delta P}{\rho} + F = 0$$

$$Re = \frac{\rho u d}{\mu} \quad \text{smooth} \hookrightarrow J_f = \frac{0.0396}{Re^{0.25}}$$

$$F_s = -\frac{\Delta P_{fs}}{\rho} = 8 J_f \left(\frac{L}{d}\right)\left(\frac{u^2}{2}\right) \Longrightarrow J_f \text{ or } u$$

Case 2 $Re = \dfrac{\rho u d}{\mu} = \text{—}$ & $J_f = \text{—}$

& $F_s = 8 J_f \dfrac{L}{d}\left(\dfrac{u^2}{2}\right) = \text{—}$

& $\dfrac{\Delta P}{\rho} + F = 0 \Longrightarrow \Delta P$

4.11 $\mu = 10\ mNs/m^2$ $\rho = 900\ kg/m^3$ $d = 500\ mm$ $L = 10\ km$
$\Delta P = 1 \times 10^6\ N/m^2$

$\Delta P = ?$ at $d = 300\ mm$

اختبار للطالب يشبه مثال 4.10

4.12 $\rho = 950\ kg/m^3$ $\mu = 10^{-2}\ Ns/m^2$ $L = 10\ km$ امتحان الطالب

$\Delta P = 2 * 10^5\ N/m^2$

min. diam. $= d = ?$ $Q = 50\ ton/hr$ smooth

$f = 0.079/Re^{\frac{1}{4}}$

$\dot{m} = \frac{50 * 10^3\ kg}{hr} = \quad kg/sec$

$Q = \dot{m} * \rho = \smile \Longrightarrow Q = U * A$ $U = ?$

$\boxed{= U * \frac{\pi}{4} d^2}$ $d = ?$

$Re = \frac{\rho U d}{\mu}$

$\boxed{U = \dots d}$

$f = \frac{0.079}{Re^{1/4}} \rightarrow U$

$\frac{\Delta P}{\rho} + F = 0 \Longrightarrow F = \smile$

$F = -\frac{\Delta P_{fr}}{\rho} = 8 f \left(\frac{L}{d}\right)\left(\frac{U^2}{2}\right) \Longrightarrow U = \smile$

$\therefore Q = U * A$

$\therefore d = \smile$

4.13

$d = 0.5\,m$ $L = 1200\,m$ $\rho = 950$ $\mu = 0.01$

$Q = 0.4\,m^3/s$ $e = 0.5\,mm$

$\Delta P = ?$

اختبار للطالب . تشبه الامثلة

4.12
4.11
4.10

4.14 two phase $\rightarrow$ ① $\Rightarrow$ $\rho = 1000$ $\mu = 1$ mNs/m

$\rightarrow$ ② $\Rightarrow$ $\rho = 1050$ $\mu = 10$

$\dot{m}_{water} = 4$ kg/s $d = 50$ mm

Smooth

$$G = \dot{m}/A = \text{—}$$

$$\omega = \frac{4}{4+4} = 0.5$$

$$Re_L)_{Glyc.} = \frac{\rho u d}{\mu} = \frac{\rho Q d}{A \mu} = \frac{\dot{m} \times d}{A \mu} = \text{—}$$

$$Re_L)_{water} = \frac{\dot{m} \times d}{A \mu} = \text{—}$$

$$X_n = \left(\frac{1-\omega}{\omega}\right)^{0.9} \left(\frac{\mu_L}{\mu_G}\right)^{0.1} \left(\frac{\rho_G}{\rho_L}\right)^{0.5} = \text{—}$$

$$\Phi_L^2 = \text{—} \quad \text{for } C = \text{—} \Rightarrow \Phi_L^2 = \text{—}$$

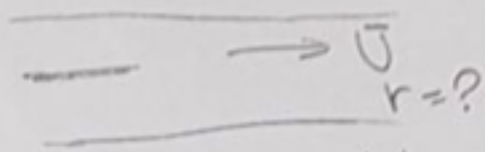
$$Re_L)_{Glyc.} = \text{—} \ \& \ e/d = \text{—} \Rightarrow f = \text{—}$$

$$\left(\frac{dP}{dl}\right)_L = \overset{8f}{4f} \frac{1}{d} \frac{G^2 (1-\omega)^2}{2\rho_L} = \text{—}$$

$$\left(\frac{dP}{dl}\right)_T = \Phi_L^2 \left(\frac{dP}{dl}\right)_L = \text{—}$$

4.15

$d =$ —
$R = d/2$



$U_x = \bar{U}$

$$\bar{U} = \frac{Q}{A} = \frac{Q}{\pi R^2}$$

$$\boxed{\bar{U} = 0.82\, U_{max}}$$

$$\frac{U_x}{U_{max}} = \left(1 - \frac{r}{R}\right)^{1/7}$$

$$\frac{U_x}{\bar{U}/0.82} = \left(1 - \frac{r}{R}\right)^{1/7}$$

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at $U_x = \bar{U}$

$$\cancel{\frac{U_x}{\bar{U}/0.82}} = 0.82 = \left(1 - \frac{r}{R}\right)^{1/7}$$

$$1 - \frac{r}{R} = 0.25 \Longrightarrow \frac{r}{R} = 0.75$$

$$r = 0.75\, R = 0.75\, \frac{d}{2}$$

$$\boxed{r = 0.375\, d}$$

4.16

$d = 25\ mm$
$L = 5\ m$ $\quad \Delta P = 8000\ N/m^2$ $\quad \rho = 1000\ kg/m^3$ (Smooth)
$Q = 110\ ton/h$ $\quad \mu = 1\ mNs/m^2$

(10% of tubes blocked) $\Longrightarrow \Delta P = ?$

$\dot{m} = 110\ ton/h \Longrightarrow Q_1 = U_1 * A_1$

$Q_1 = Q_2 = U_2 * A_2$

$A_2 = (1 - 0.1) * A_1 \Longrightarrow A_2 = 0.9 A_1$

$\boxed{U_1 * A_1 = U_2 * 0.9 A_1} \Longrightarrow \boxed{U_1 = 0.9\ U_2} = \_\_$

4.6 والباقي شبه المثال