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HW10 Answer template

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Problem 1

$Re = \frac{v \cdot \rho \cdot D}{\mu} = 4.12 \times 10^4 \rightarrow$ turbulent

$C_d = f(\beta) + 91.71 \beta^{2.5} Re^{-0.75} + 0 - 0$

$f(\beta) = 0.5959 + 0.0312 \beta^{2.1} - 0.184 \beta^8$

$f(\beta) = 0.602$

$\therefore C_d = 0.614$

$Q = C_d A_t \sqrt{\frac{2\Delta P}{\rho(1-\beta^4)}}$

$\frac{2\Delta P}{\rho(1-\beta^4)} = \left(\frac{Q}{C_d A_t}\right)^2 \rightarrow \Delta P = \frac{Q^2 \rho (1-\beta^4)}{C_d^2 A_t^2 \, 2}$

$\Delta P = 319. \text{ Pa}$

$Q = 3 \frac{m^3}{h} = 8.33 \times 10^{-4} \frac{m^3}{sec}$

$D = 0.06 \text{ m}$

$d = 0.04 \text{ m}$

$A = \frac{\pi D^2}{4} = 2.827 \times 10^{-3} \text{ m}^2$

$v = \frac{Q}{A} = 0.2947 \frac{m}{sec}$

$\rho = 680 \frac{Kg}{m^3}$

$\mu = 2.92 \times 10^{-4} \frac{Kg}{m \cdot s}$

$\beta = \frac{d}{D} = 0.667$

$A_t = \frac{\pi d^2}{4} = 1.257 \times 10^{-3} \text{ m}^2$

319. Pa

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Problem 2

(a)

$$Re = \frac{\rho v D}{\mu} \rightarrow D = \frac{Re\,\mu}{\rho v}$$

$Re = 1$
$\rho = 998$
$v = 0.25$
$\mu = 1 \times 10^{-3}$

$$D = 4.01 \times 10^{-6}\ m$$

$4.01\ \mu m$

(b)

$Re = 250000$

$$D = \frac{Re\,\mu}{\rho v} = 1.00\ m$$

$1.00\ m$

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Problem 3

$H = \frac{\delta^*}{\theta}$

eq. 7.6: $\theta \approx \frac{2}{15}\delta$

eq. 7.13: $\delta^* \approx \frac{1}{3}\delta$

$\therefore H = \frac{\frac{1}{3}\delta}{\frac{2}{15}\delta} = \frac{1}{3} \cdot \frac{15}{2} = \frac{15}{6} = \frac{5}{2} < 2.59$

H:

2.5

Larger/smaller than Blasius?

Smaller

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Problem 4

SAE 10

(a)

$\rho = 870 \frac{kg}{m^3}$

$\mu = 0.104 \frac{kg}{m \cdot sec}$

$v = 6 \frac{m}{sec}$

$$Re = \frac{\rho v \cdot 1.1}{\mu} = 5.52 \times 10^4 \rightarrow \text{Laminar}$$

$$C_D = \frac{1.328}{Re^{1/2}} = 5.65 \times 10^{-3}$$

$$D = \frac{\rho v^2 b \cdot L \cdot x \cdot C_D}{2} = 1.07 \times 10^2 \, N$$

$1.07 \times 10^2 \, N$

(b)

$$Re = \frac{\rho v \cdot 0.55}{\mu} = 2.76 \times 10^4$$

$$C_D = \frac{1.328}{Re^{1/2}} = 7.99 \times 10^{-3}$$

$$D = \rho v^2 \cdot A \cdot C_D = 1.51 \times 10^2 \, N$$

151. N

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Problem 5

(a) $Re = \frac{\rho V L}{\mu} = 2.54 \times 10^6 \rightarrow$ transition

$\rho = 1.2 \frac{kg}{m^3}$

$\mu = 1.8 \times 10^{-5} \frac{kg}{m \cdot sec}$

$V = 15.65 \frac{m}{sec}$

$L = 8 ft = 2.438 m$

Lam: $\frac{\delta}{L} = \frac{5}{\sqrt{Re}} \rightarrow \delta = \frac{5 \cdot 2.438}{\sqrt{Re}} = 7.64 \times 10^{-3}$

If laminar:

7.64×10^{-3} m

Turb: $\frac{\delta}{L} = \frac{0.16}{Re^{1/7}} = 4.74 \times 10^{-2}$

If turbulent:

4.74×10^{-2} m

(b)

$C_D = \frac{1.328}{Re^{1/2}} = 8.33 \times 10^{-4}$

$D = C_D \frac{\rho}{2} V^2 b L = 0.727$

0.727 N

(c)

$C_D = \frac{0.031}{Re^{1/7}} = 3.77 \times 10^{-3}$

$D = C_D \rho V^2 b L = 3.29$

3.29 N

$D_{turb} > D_{Lam}$

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Problem 6

$L = 0.9144\ m$

boron

$\rho = 1025\ \frac{kg}{m^3}$

$\mu = 1.07 \times 10^{-3}\ \frac{kg}{m \cdot sec}$

$v = 5.14\ m/sec$

$b = 2.134$

$$Re = \frac{\rho v L}{\mu} = 4.5 \times 10^6 \rightarrow turb$$

$$C_D = \frac{0.031}{Re^{1/7}} - \frac{1440}{Re} = 3.15 \times 10^{-3}$$

$$D = \not{2} C_D \frac{\rho}{\not{2}} v^2 \cdot bL$$

$$= 167.\ N$$

167. N

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Problem 7

(a)

$$\frac{U}{u^*} \simeq \frac{1}{\kappa} \ln\left(\frac{y u^*}{\nu}\right) + B \qquad \tau = \rho u^{*2}$$

$B = 5.0$
$\nu = 1.5 \times 10^{-5}$
$U = 10 \frac{m}{sec}$
$\kappa = 0.41$
$\rho = 1.2 \frac{kg}{m^3}$

$$10 = \frac{u^*}{\kappa} \ln\left(\frac{80 u^*}{\nu}\right) + B u^* \rightarrow u^* = 0.254 \frac{m}{sec}$$

$$\therefore \tau = 0.0771 \text{ Pa}$$

$$\frac{U}{0.254} \simeq \frac{1}{\kappa} \ln\left(\frac{1.7(0.254)}{1.5 \times 10^{-5}}\right) + 5$$

$$\rightarrow U \simeq 7.62 \frac{m}{sec}$$

$7.62 \frac{m}{sec}$

(b)

$$U \simeq 0.254 \left(\frac{1}{\kappa} \ln\left(\frac{0.17(0.254)}{1.5 \times 10^{-5}}\right) + 5\right)$$

$$\simeq 6.19 \frac{m}{sec}$$

$6.19 \frac{m}{sec}$

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Problem 8

Lam

$$\frac{\delta}{L} = \frac{5}{Re^{1/2}} = 0.00559$$

$$= 5.59 \times 10^{-3}$$

Turb

$$\frac{\delta}{L} = \frac{0.16}{Re^{1/7}} = 2.30 \times 10^{-2}$$

assume $L_a = L_b \rightarrow \delta_{turb} \approx 4\,\delta_{Lam}$

True