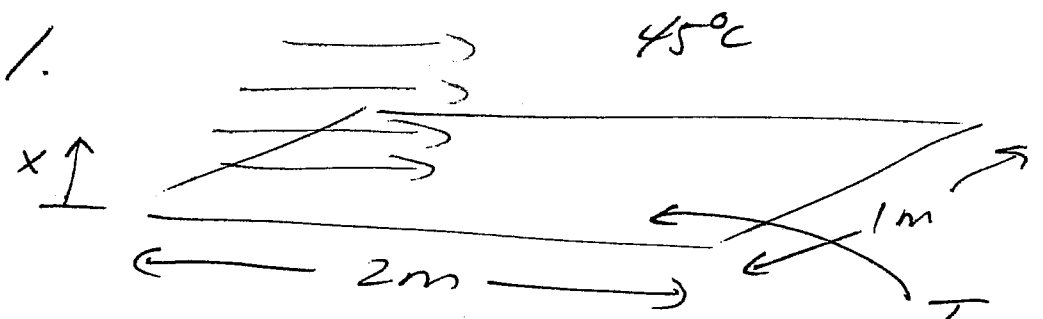
Mini Exam 4

4 Dec 07

CM3110

1.



$V_{water} = 0.02 \frac{m}{s}$

$\left| \frac{q_x}{A} \right| = ?$

$$q = h A (\bar{T}_b - \bar{T}_s)$$

↑ mid h

From Geankoplis 4th Ed: (p271)

Flow parallel to a flat plate:

$$Nu = a\, Re^{b}\, Pr^{c}$$

a, b, c depend on laminar vs. turbulent

$$Re = \frac{\rho V L}{\mu} = \frac{\left(994.7 \frac{kg}{m^3}\right)\left(0.021 \frac{m}{s}\right)(2m)}{0.682 \times 10^{-3} \frac{kg}{m\,s}}$$

$\mu(T_f) = ?$

$$T_f = \frac{T_w + T_b}{2} = \frac{30.6 + 45}{2} = 37.8\,^\circ C$$

$$\mu(37.8\,^\circ C) = 0.682 \times 10^{-3} \frac{kg}{m\,s}$$ p947 Geankoplis

$$Re = 61{,}257 \Rightarrow \text{laminar} \quad (Re < 3 \times 10^5)$$

$$Nu = \frac{hL}{k} = 0.664\, Re^{0.5}\, Pr^{1/3}$$

$Pr(T_f) = 4.51$ p947

$$\frac{hL}{k} = 0.668 (61,257)^{0.5} (4.51)^{\frac{1}{3}}$$

$$= 271.52$$

$$h = \left(0.6283 \frac{W}{mK}\right)\left(\frac{1}{2m}\right)(271.52)$$

$$\boxed{h = 85.298 \frac{W}{m^2K}}$$

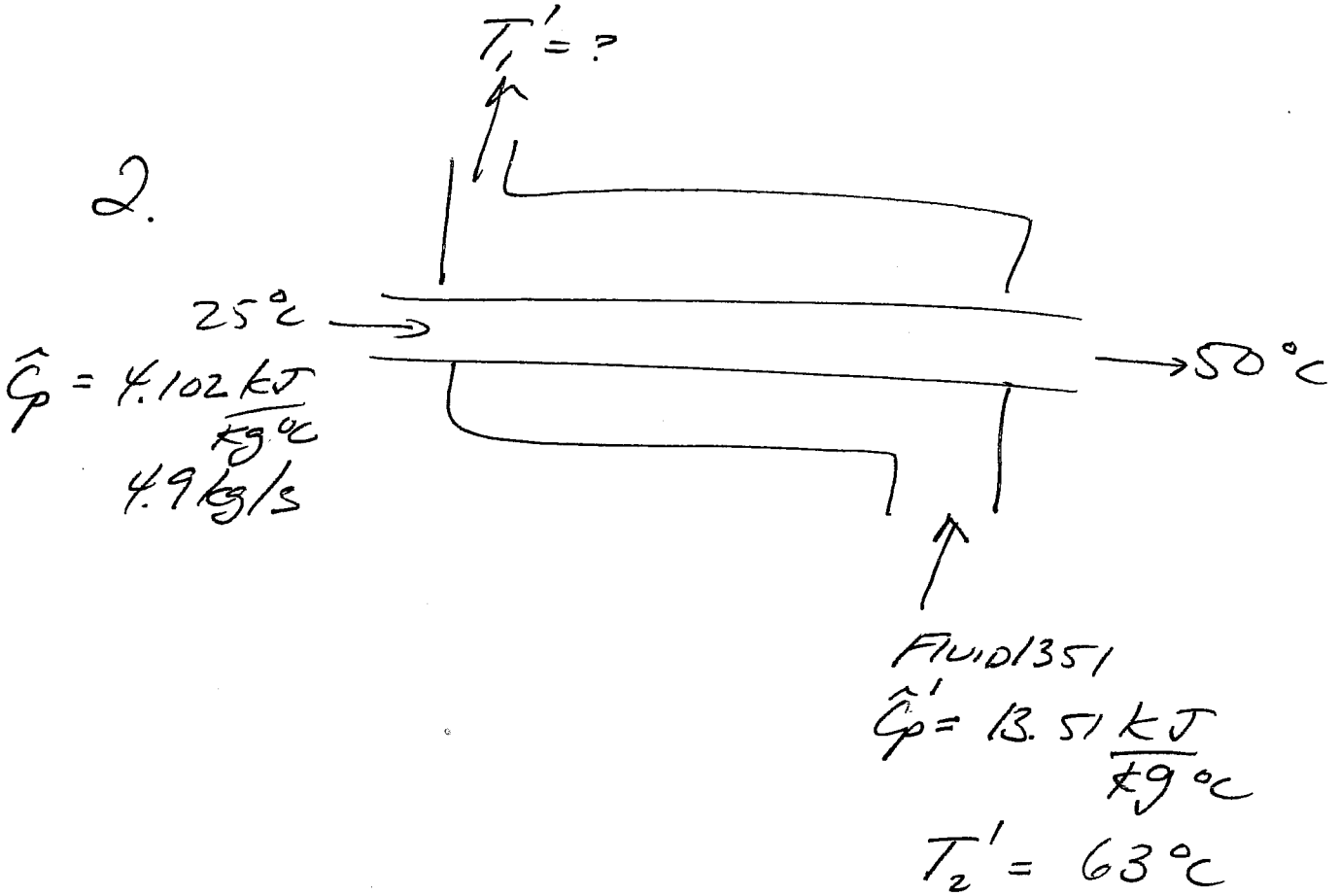
$$\frac{q}{A} = h (T_b - T_s)$$

$$= \left(\frac{85.298 W}{m^2 K}\right)(45 - 30.C)^{\circ}$$

$$= 1228.29 \frac{W}{m^2}$$

$$= \boxed{1200 \frac{W}{m^2} \quad 2 \text{ SIG FIGS}}$$

2.



Is flow rate the same as before? Are temps same?

NO

m' changes

EBAL INSIDE:

$$Q = m \hat{C}_p \Delta T$$

inside fluid

this is the same since the E-bal on the inside fluid is the same

EBAL OUTSIDE:

$$Q = m' \hat{C}_p' \Delta T'$$

$\Rightarrow$ different

different

$\Rightarrow$ different

changes

also $Q = UA\,\underbrace{\Delta T_{ln}}_{\text{changes}}$

Temp out changes

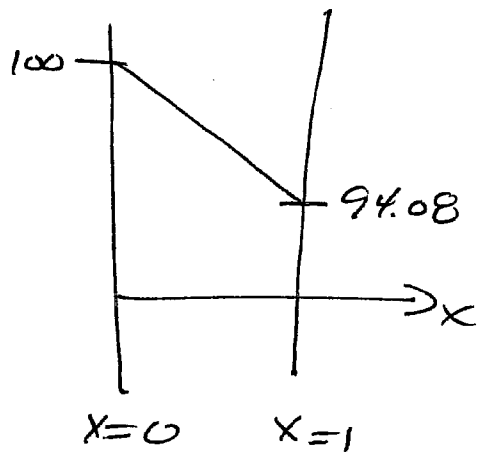
U depends on h_1, h_2 which depend on $Re \Rightarrow$ depend on m and m'

$$U = \frac{\frac{1}{R}}{\frac{1}{h_1 R_1} + \frac{1}{k}\ln\frac{R_2}{R_1} + \frac{1}{h_2 R_2}}$$

h_1 depends on Re, Pr which change $\therefore U$ may change

Heat conduction in a slab

3. $T = -5.92x + 100$



for a slab:

$$T = -\frac{C_1}{K}x + C_2$$

compare

$$\frac{q}{A} = C_1$$

$$-\frac{C_1}{K} = -5.92\left(\frac{^\circ C}{m}\right)$$

$$C_1 = (5.92)k$$

$$= (5.92)\left(5.012\ \frac{W}{m\cancel{K}}\right)\frac{\cancel{K}}{m}$$

$$= 29.67\ \frac{W}{m^2}$$

$$\frac{q_x}{A} = C_1 = 29.67 \frac{W}{m^2}$$

$$\frac{q_x}{A} = 30 \frac{W}{m^2}$$ 2 SIG FIGS (3 OK ALSO)