Chapter 1

1-1 (a) 98 Btu/(hr-ft-F) x1.7307 = 170 W/(m-K)

(b) 0.24 Btu/(lbm-F) x4186.8=1.0 kJ/kg-K

(c) $\frac{0.04 \text{ lbm/(ft-hr)}}{3600 \text{ sec/hr}} \text{ x}1.488 = 16.5 \frac{\mu\text{Ns}}{\text{m}^2}$

(d) $1050 \frac{\text{Btu}}{\text{lbm}} \text{ x } \frac{1}{9.48\text{x}10^{-4}} \frac{\text{J}}{\text{Btu}} \text{ x } \frac{2.20462 \text{ lbm}}{\text{kg}} = 2.44 \frac{\text{MJ}}{\text{kg}}$

(e) $12{,}000 \frac{\text{Btu}}{\text{lbm}} \text{ x } \frac{1}{3.412} = 3.52 \text{ kW}$

(f) $14.7 \frac{\text{lbf}}{\text{in}^2} \text{ x } 6894.76 = 101 \text{ kPa}$

1-2 (a) $120 \text{ kPa x } \frac{\text{lbf}/\text{in}^2}{6.89476\text{kPa}} = 17.4 \text{ lbf/in}^2$

(b) $100 \frac{\text{W}}{\text{m}-\text{K}} \text{ x } 0.5778 = 57.8 \text{ Btu/hr-ft-F}$

(c) $0.8 \frac{\text{W}}{\text{m}^2-\text{K}} \text{ x } 0.1761 = 0.14 \text{ Btu/hr-ft}^2\text{-F}$

(d) $10^{-6} \text{ N-s/m}^2 \text{ x } \frac{1}{1.488} = 6.7 \text{ x } 10^{-7} \frac{\text{lbm}}{\text{ft}-\text{sec}}$

(e) $1200 \text{ kW x } 3412 = 4.1 \text{ x } 10^{-6} \text{ Btu/hr}$

$$\text{(f) } 1000\ \frac{\text{kJ}}{\text{kg}}\ \text{x}\ \frac{1\ \text{Btu}}{1.055\ \text{kJ}}\ \text{x}\ \frac{1\ \text{kg}}{2.2046\ \text{lbm}} = 430\ \frac{\text{Btu}}{\text{lbm}}$$

1-3 $\text{Hp} = 50\ (\text{ft}) \times 0.3048\ \left(\frac{\text{m}}{\text{ft}}\right) = 15.2\ \text{m}$

$$\Delta P = \frac{15.2\ \text{m}}{1000\ \text{Pa/kPa}}\ \text{x}\ \frac{9.807}{1}\ \left(\frac{\text{N}}{\text{kg}}\right)\ \text{x}\ 1000\ (\text{kg/m}^3) = 149\ \text{kPa}$$

1-4 $\Delta P = \frac{4}{12}\ (\text{ft}) \times 0.3048\ \left(\frac{\text{m}}{\text{ft}}\right) \times \frac{9.807}{1}\ \left(\frac{\text{N}}{\text{kg}}\right) \times 1000\ \left(\frac{\text{kg}}{\text{m}^3}\right)$

$$\Delta P = 996\ \text{Pa} \approx 1.0\ \text{kPa}$$

1-5

TOTAL BILL = ENERGY CHARGE + DEMAND CHARGE

+ METER CHARGE

$$(96{,}000)\ \text{kw - hrs}\ (0.045)\$/\text{kw}-\text{hr} + (624)\text{kw}(11-50)\$/\text{kw}$$

$$+ \$68 = \$4{,}320 + \$7{,}176 + \$68 = \$11{,}564$$

1-6 7 AM to 6 PM ⟶ 11 hrs/day, 5 days/wk

$$(11)\frac{\text{hrs}}{\text{day}}\ (22)\frac{\text{days}}{\text{months}} = 242\ \text{hrs}/\text{month}$$

$$\text{ratio} = \frac{(624)\text{kw}}{\left(\frac{(96{,}000)\text{kw}-\text{hr}}{(242)\text{hr}}\right)} = 1.57$$

1-7 This is a trial and error solution since eq. 1-1 cannot be solved explicitly for i.

Answer converges at just over 4.2% using eq. 1-1

1-8 Determine present worth of savings using eq. 1-1

$$P = \frac{(\$1000)\left[1\text{-}\left(1+\frac{0.012}{12}\right)^{-(12)(12)}\right]}{\left(\frac{0.012}{12}\right)}$$

$$P = \$134{,}000$$

1-9 (a) $\dot{Q} = \bar{V}A = 2 \text{ x } 3.08 \text{ x } 10^{-3} = 6.16 \text{ x } 10^{-3} m^3/s$

$\dot{m} = \rho\dot{Q} = 6.16 \text{ x } 10^{-3} \text{ x } 998 = 6.15$ kg/s

(b) $A = \frac{\pi}{4}(0.3)^2 = 7.07 \text{ x } 10^{-2}\ m^2$

$\dot{Q} = 7.07\text{x}10^{-2} \text{ x } 4 = 0.283\ m^3 / s$; $\rho = 1.255\ kq/m^3$

$\dot{m} = 1.225 \text{ x } 0.283 = 0.347$ kg/s

1-10 $V = 3\text{x}10\text{x}20 = 600m^3$

$$\dot{Q}_i = 600 \times \frac{1}{4} \times \frac{1}{3600} = 4.17 \times 10^{-2}\ m^3/s$$

1-11

$\dot{q} = \dot{m} c_p \Delta T$ $c_p = 4.183$ kJ/(kg-K)

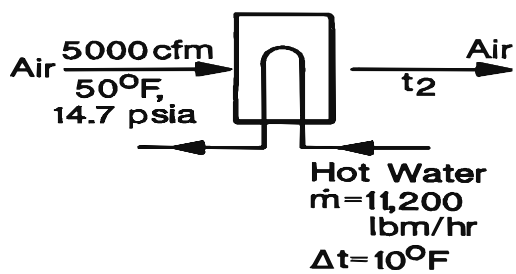
$\rho = 983.2\ kg/m^3$

1-11 (cont'd)

$$\dot{q} = (1)\frac{m^3}{s}(983.2)\frac{kg}{m^3}(4.183)\frac{kJ}{kg-K}(5)^c = 20{,}564\frac{kJ}{s}$$

$\dot{q}$ = 20,564 kw

1-12 $\dot{q}_{wat} = -\dot{q}_{air}$



11,200(1)(10) =

$$= \frac{5000 x 60 x 14.7 x 144 x 0.24 (t_2 - 50)}{(53.35 x 510)}$$

11,200 = 5601.5 (t_2-50); t_2 = (11,200/5601.5) + 50 = 70 F

1-13 Diagram as in 1-12 above.

$\dot{q}_{wat} = -\dot{q}_{air}$

1.5 (4186)(90-t_2) = 2.4 (1.225)(1.0)(30-20)(1000)

6279(90-t_2) = 29,400

$$t_2 = 90 - \frac{29,400}{6279} = 85.3 \text{ C}$$

1-14 $\dot{q} = hA(t_s - t_\infty)$

A= π (1/12) x 10 = 2.618 ft^2

$t_s = t_{sur} \approx 212$ F

$\dot{q}$ = 10x2.618x(212-50) = 4241 Btu/hr

1-15 A= π x 0.25x4 = 3.14 16 m^2

$\dot{q} = hA(t_s - t_\infty)$

$$h = \frac{\dot{q}}{A(t_s - t_\infty)} = \frac{1250}{3.1416(100-10)} \text{ ; } h = 4.42 \text{ W/(m}^2 - \text{C)}$$

1-16 $\dot{q} = \dot{m}c_p(t_2 - t_1)$; $\dot{m} = \dot{Q}$ x ρ

$\rho =$ P/RT = 14.7x144/53.35(76+460)

ρ = 0.074 lbm/ft^3

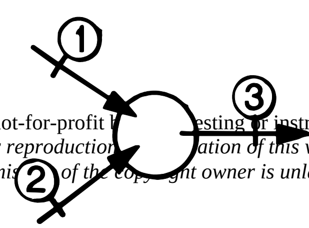
$\dot{m}$ = 5000x0.074x60 = 22,208 lbm/hr

c_p = 0.24 Btu/lbm-F

$\dot{q}$ = 22,208x0.24(58-76) = -95,939 Btu/hr

Negative sign indicates cooling

1-17 $\dot{m}_1 c_p\ (t_3 - t_1)$ +



$$\dot{m}_2 c_{p2} (t_3 - t_2) = 0$$

$$c_{p1} = c_{p2}$$

$$t_3 = \frac{(\dot{m}_1 t_1 + \dot{m}_2 t_2)}{(\dot{m}_1 + \dot{m}_2)}$$

$$\dot{m}_1 = \dot{Q}_2 \rho_1 = 1000\text{x} \frac{14.7\text{x}144}{53.35(460+50)} = 73.5 \text{ lbm/min}$$

1-17 (cont'd)

$$\dot{m}_2 = \dot{Q}_2 \rho_2 = 600\text{x} \frac{14.7\text{x}144}{53.35(460+50)} = 46.7 \text{ lbm/min}$$

$$t_3 = \frac{(73.5\text{x}80) + (46.7 \text{ x } 50)}{(73.5 + 46.7)} = \underline{\underline{68.3 \text{ F}}}$$