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## Chapter 1

1-1 (a)  $98 \text{ Btu}/(\text{hr}\cdot\text{ft}\cdot\text{F}) \times 1.7307 = 170 \text{ W}/(\text{m}\cdot\text{K})$

(b)  $0.24 \text{ Btu}/(\text{lbm}\cdot\text{F}) \times 4186.8 = 1.0 \text{ kJ}/\text{kg}\cdot\text{K}$

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

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

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

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

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

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

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

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

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

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

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

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

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

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

1-5

TOTAL BILL = ENERGY CHARGE + DEMAND CHARGE

+ METER CHARGE

$$(96,000) \text{ kw - hrs } (0.045) \$/\text{kw - hr} + (624) \text{kw} (11 - 5) \$/\text{kw}$$

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

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

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

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

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

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

$$P = \$134,000$$

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

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

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

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

$$\dot{m} = 1.255 \times 0.283 = 0.347 \text{ kg/s}$$

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

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

1-11

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

$$\rho = 983.2 \text{ kg}/\text{m}^3$$

1-11 (cont'd)

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

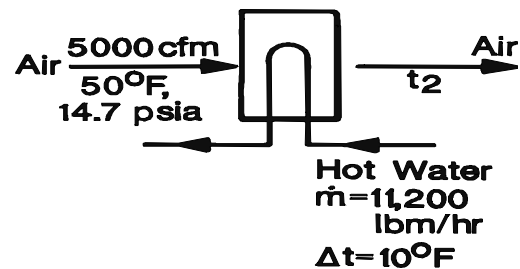
$$\dot{q} = 20,564 \text{ kw}$$

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

$$11,200(1)(10) =$$

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

$$11,200 = 5601.5(t_2 - 50); t_2 = (11,200/5601.5) + 50 = 70 \text{ F}$$



1-13 Diagram as in 1-12 above.

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

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

$$6279(90 - t_2) = 29,400$$

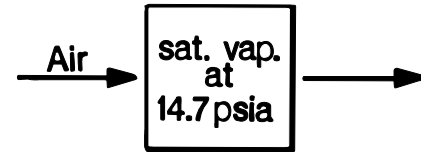
$$t_2 = 90 - \frac{29,400}{6279} = 85.3 \text{ C}$$

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

$$A = \pi (1/12) \times 10 = 2.618 \text{ ft}^2$$

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

$$\dot{q} = 10 \times 2.618 \times (212 - 50) = 4241 \text{ Btu/hr}$$



$$1-15 \quad A = \pi \times 0.25 \times 4 = 3.1416 \text{ m}^2$$

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

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

$$1-16 \quad \dot{q} = \dot{m}c_p(t_2 - t_1) ; \dot{m} = \dot{Q} \times \rho$$

$$\rho = P/RT = 14.7 \times 144 / 53.35(76 + 460)$$

$$\rho = 0.074 \text{ lbm/ft}^3$$

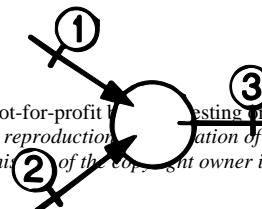
$$\dot{m} = 5000 \times 0.074 \times 60 = 22,208 \text{ lbm/hr}$$

$$c_p = 0.24 \text{ Btu/lbm-F}$$

$$\dot{q} = 22,208 \times 0.24(58 - 76) = -95,939 \text{ Btu/hr}$$

Negative sign indicates cooling

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



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

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

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

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

1-17 (cont'd)

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

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