Josh Whitehead
Ch En 3453

HW #1

1.) $A = 0.1\ m^2$ $\quad T_\infty = 20°C$ $\quad h = 120 \frac{W}{m^2 K}$
$q''_{in} = 1800 \frac{W}{m^2}$

$Accum = In - out + gen \rightarrow In = out$
$q''_{in} = q''_{out}$

$\therefore q'' A = 5A\, h (T - T_\infty) \rightarrow \frac{q''}{5h} = T - T_\infty$

$\rightarrow T = T_\infty + \frac{q''}{5h} = 20°C + \frac{1800 \frac{W}{m^2}}{5 \cdot 120 \frac{W}{m^2 K}}$ $\boxed{= 23°C}$

2.) $L = 10\ cm = 0.10\ m$ $\quad \dot{q} = 50000 \frac{W}{m^3}$ $\quad T_\infty = 20°C$
$h = 120 \frac{W}{m^2 K}$

$Accum = In - out + gen \rightarrow gen = out$
$\dot{q}V = 5A\, q''_{out}$

$\Rightarrow \dot{q}V = 5Ah (T - T_\infty) \rightarrow T = \frac{\dot{q}V}{5Ah} + T_\infty$

$= \frac{50000\ (0.001)}{5\ (0.01)\ (120)} + 20$ $\boxed{= 28.3°C}$

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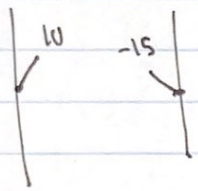
3) a) $T = 0.005\ m$ $\quad W = 1\ m$ $\quad H = 2\ m$ $\quad k = 1.4 \frac{W}{mK}$

Cond: $q'' = \frac{-k}{L}(\nabla T) = \frac{-k}{L}(T_2 - T_1)$

Accum = In − out + gen ∴ In = out

$q = A q'' = 2\,m^2 \cdot \frac{-1.4 \frac{W}{mK}}{0.005\,m}(-20-15)K$ $\boxed{= 19{,}600\ W}$

b.)



$k_{air} = 0.024 \frac{W}{mK}$ $\quad L = 0.01\ m$

$W = 1\ m$ $\quad H = 2\ m$

$q'' = \frac{-k}{L}(T_2 - T_1) \rightarrow q = \frac{-kA}{L}(T_2 - T_1)$

$= \frac{(-0.024)(2)}{0.01} \cdot (-15-10)$ $\boxed{= 120\ W}$

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4) a) $A = 0.005^2\ m^2$ $\quad T_\infty = 15°C$ $\quad T = 85°C$

$h_{air} = 200 \frac{W}{m^2 K}$

$q_{max} = Ah(T - T_\infty) = 0.005^2 \cdot 200\,(85-15)$ $\boxed{= 0.35\ W}$

b) $h_{fluid} = 3000 \frac{W}{m^2 K} \rightarrow q_{max} = A h_{fluid}(T - T_\infty)$

$= 0.005^2\,(3000)\,(85-15)$

$\boxed{= 5.25\ W}$

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HW #1

5.) $\frac{dT}{dt} = -0.022 \frac{K}{s}$ $T = 225°C$ $T_{air} = 25°C$

$A = 0.09\ m^2$ $m = 3.75\ kg$ $C_p = 2770 \frac{J}{kg\,K}$

$Accum = In - out + gen \rightarrow Accum = -out$

$\frac{dT}{dt} \cdot C_p \cdot m = -2Ah(T - T_{air})$

$\therefore h = \frac{\frac{dT}{dt} \cdot C_p \cdot m}{-2A\Delta T} = \frac{-0.022 \cdot 2770 \cdot 3.75}{-2(0.09) \cdot 200} = 6.35 \frac{W}{m^2 K}$

6.) $\Theta = 5.67 \times 10^{-8}$ $T_{air} = 298.15\ K$ $T = 498.15\ K$

$A = 0.09\ m^2$

$Accum = -out + gen$

$Accum = -out$

$\frac{dT}{dt} \cdot C_p \cdot m = -2A\varepsilon\Theta(T^4 - T_{air}^4)$

$\rightarrow \frac{\frac{dT}{dt} \cdot C_p \cdot m}{-2A\Theta(T^4 - T_{air}^4)} = \varepsilon = 0.417$

$q'' = \varepsilon\Theta(T^4 - T_{air}^4) = 0.417(5.67 \times 10^{-8})(498.15^4 - 298.15^4)$

$= 1269.6 \frac{W}{m^2}$

$q = Aq'' = 1269.6 \cdot 2 \cdot 0.09 = 229.\ W$

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HW #1

7.) a.) Accum = In - out + gen → In = out → ~~$h_1(T_\infty - T_1) = \frac{-k}{L}(T_2 - T_1)$~~

$$h_1(T_\infty - T_1) = \frac{-k}{L}(T_2 - T_1)$$

$$\rightarrow 130 \frac{W}{m^2 K}(120°C - T_1) = \frac{-3 \frac{W}{m^2 K}}{0.2\,m}(T_2 - T_1)$$

b.) Accum = In - out + gen → In = out →

$$\rightarrow \frac{-k}{L}(T_2 - T_1) = h_2(T_2 - T_\infty)$$

$$\rightarrow \frac{-3 \frac{W}{m^2 K}}{0.2\,m}(T_2 - T_1) = 60(T_2 - 10°C)$$

Solver → $\boxed{T_1 = 111.°C \;,\; T_2 = 30.1\,°C}$

8.) Balance 1) Accum = in - out + gen → in = out

$$\rightarrow h_1(T_{\infty_1} - T_1) = \frac{-k}{L}(T_2 - T_1)$$

Balance 2) In = out → $\frac{-k}{L}(T_2 - T_1) = h_2(T_2 - T_{\infty_2})$

Solver → $T_1 = 96.7°C \;,\; T_2 = 60.4°C$

$$q''_L = q''_{cond} = q''_R$$

$$q''_L = h_1(T_{\infty_1} - T_1) = 130(120 - 96.7°C) = 3025.4 \frac{W}{m^2}$$

$\boxed{q''_L = q''_{cond} = q''_R = 3025.4 \frac{W}{m^2}}$

Heat is flowing from left to right

$q = q'' \cdot A = 3025.4 \cdot 2.5 \cdot 6 = \boxed{45380.8\ W}$

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HW #1

9) $\varepsilon = 0.78$ $\quad \Theta = 5.67 \times 10^{-8}$ $\quad T_{sur} = 278\,K$ $\quad T_\infty = 295\,K$

$h = 120 \frac{W}{m^2 K}$ $\quad \dot{q} = 100{,}000 \frac{W}{m^3}$

Accum = In - out ~~+ gen~~ $\rightarrow$ gen = out

$V_i \dot{q} = q_{conv} + q_{rad}$

$V_i \dot{q} = A_0 h (T_s - T_\infty) + A_0 \varepsilon \Theta (T_s^4 - T_{sur}^4)$

$\rightarrow V_i \dot{q} = A_0 h T_s - A_0 h T_\infty + A_0 \varepsilon \Theta T_s^4 - A_0 \varepsilon \Theta T_{sur}^4$

$\rightarrow V_i \dot{q} + A_0 h T_\infty + A_0 \varepsilon \Theta T_{sur}^4 = A_0 h T_s + A_0 \varepsilon \Theta T_s^4$

$V_i = \frac{3}{4} \pi r_i^3 = \frac{3}{4} \pi (1)^3 = 4.19\ m^3$

$A_0 = 4 \pi r_0^2 = 4 \pi (1.1)^2 = 15.2\ m^2$

$\rightarrow 4.19(100000) + 15.2(120)(295) + 15.2(0.78)(5.67 \times 10^{-8})(278)^4$
$= 9.61 \times 10^5 = A_0 h T_s + A_0 \varepsilon \Theta T_s^4$

$\rightarrow$ Solver $\longrightarrow$ $\boxed{T_s = 503.\ K}$

b) $gen = \dot{q} \cdot V_i = 100000 \frac{W}{m^3} \cdot 4.19\ m^3 = \boxed{4.19 \times 10^5\ W}$

c) $q_{rad} = A_0 \varepsilon \Theta (T_s^4 - T_{sur}^4) = 15.2(0.78)(5.67 \times 10^{-8})(503^4 - 278^4)$

$\boxed{q_{rad} = 3.91 \times 10^4\ W}$

d) $q_{conv} = A_0 h (T_s - T_\infty) = 15.2(120)(503 - 295)$

$\boxed{q_{con} = 3.80 \times 10^5\ W}$

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HW #1

10) Acc = in - out + gen → In = out

$q'' = h(T_{s3} - T_\infty) \rightarrow$ ~~$900 \frac{W}{m^2} = 40 \frac{W}{m^2 K}(T_{s3} - 25°C)$~~

$T_{s3} = T_\infty + \frac{q''}{h} = 25°C + \frac{900 \frac{W}{m^2}}{40 \frac{W}{m^2 K}}$ $\boxed{= 47.5°C}$

Problem #7

T1	T2
110.7042219	30.14081

surf(1)
-6.41065E-06

surf(2)
-0.002480818

Problem #8

T1	T2
96.72780436	60.42318

surf(1)
0.000108988

surf(2)
0.005505169

q'' (w/m2)	q (w)
3025.385433	45380.78

Problem #9

Ao	Vi
15.2053084	4.18879

surf	Ts
0.00062163	503.1494