2010 Heat Transfer Midterm Exam (Including Solutions)

Now, knowing k, isolate h_c in Eq. I:

$$\frac{1}{h} + \frac{1}{h_c} = \frac{L^2}{kD}\left[\cosh^{-1}\left(\frac{T_w - T_\infty}{T_m - T_\infty}\right)\right]^{-2}$$

$$h_c = \frac{1}{-\frac{1}{h} + \frac{L^2}{kD}\left[\cosh^{-1}\left(\frac{T_w - T_\infty}{T_m - T_\infty}\right)\right]^{-2}}$$

Substitute values: $T_w = 110°C$, $T_m = 70°C$, $T_\infty = 10°C$,
$k = 50.74\ W/m°C$, $D = 0.01m$,
$h = 22\ W/m^2°C$

$$h_c = \frac{1}{-\frac{1}{22\ W/m^2°C} + \frac{(0.20m)^2}{50.74\ W/m°C \times 0.01m}\times\left[\cosh^{-1}\left(\frac{110°C - 10°C}{70°C - 10°C}\right)\right]}$$

This yields:

$$\boxed{h_c = 50.35\ W/m^2°C}$$ (A)

HOW THE MIDTERM IS SCORED:

QUESTION 1:

- 5 PTS ASSUMPTIONS
- 10 PTS TO FIND $q_{GEN\ TOTAL} = S_0 4\pi (r_o^3/6)$
- 5 PTS TO FIND $q_{CONV.\ TOTAL} = q_{GEN\ TOTAL}$ AT S-S
- 5 PTS TO FIND $T_w = T_\infty + S_0 r_o/6h$

QUESTION 2:

- 6 PTS ASSUMPTIONS
- 5 PTS TO FIND $q = \dfrac{T_i - T_\infty}{\dfrac{\ln(r_o/r_i)}{k_{ALU}\,2\pi L} + \dfrac{1}{h\,2\pi r_o L}}$
- 5 PTS TO FIND $q = S_{GEN} = \dfrac{R_{ELEC}\, I^2 L}{\pi r_i^2}$
- 4 PTS TO FIND $h = 7\ W/m^2{}^\circ C$ AND $T_i = 80^\circ C$
- 5 PTS TO OBTAIN $r_i = 6\ mm$

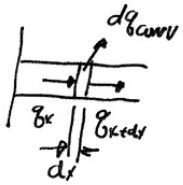
QUESTION 3

- 5 POINTS FOR ASSUMPTIONS
- 5 POINTS TO FIND $Q/Q_0 = 0.8$
- 3 POINTS TO FIND $Bi^2 Fo = 1.0$ FROM HEISLER CHARTS KNOWING $Bi = 0.5$ AND $Q/Q_0 = 0.8$
- 3 POINTS TO FIND $t = 4000\,s$ FROM $Bi^2 Fo = 1.0$
- 3 POINTS TO FIND $Fo = 4.0$ (AND $x = L$ FOR $T = T_{MAX}$)
- 4 POINTS TO SCALE $\frac{T_{MAX} - T_\infty}{T_i - T_\infty} = \underbrace{\frac{T_0 - T_\infty}{T_i - T_\infty}}_{\text{MIDPLANE TEMP. CHART}} \times \underbrace{\frac{T_{MAX} - T_\infty}{T_0 - T_\infty}}_{\text{TEMP. DISTRIBUTION CHART.}}$
- 2 POINTS TO FIND $\frac{T_{MAX} - T_\infty}{T_i - T_\infty} = 0.2 \times 0.8$ AND $T_{MAX} = 445^\circ C$

QUESTION 4

- 5 POINTS FOR ASSUMPTIONS
- 4 POINTS TO OUTLINE:

$q_x = q_{x+dx} + dq_{conv.}$



- 2 POINTS TO SCALE
  - $q_x = -k \frac{dT}{dx} \frac{\pi D^2}{4}$
  - $q_{x+dx} = -k \frac{dT}{dx} \frac{\pi D^2}{4} - \frac{d}{dx}\left(\frac{k\pi D^2}{4} \frac{dT}{dx}\right) dx + \ldots$
- 2 POINTS TO SCALE:

$$dq_{conv} = \frac{-\Delta T}{\Sigma R} = \frac{-(T_\infty - T)}{\frac{1}{h\pi D dx} + \frac{1}{h_c \pi D dx}}$$

- 2 POINTS TO FIND
  - $\theta = A\sinh(mx) + B\cosh(mx)$
  - $m^2 = \frac{4}{kD\left(\frac{1}{h} + \frac{1}{h_c}\right)}$
- 2 POINTS FOR B.C. @ $x=0$, $T = T_w$
- 2 POINTS FOR B.C. @ $x = L/2$, $d\theta/dx = 0$
- 2 POINTS TO OBTAIN $\frac{\bar{T}_m - T_\infty}{T_w - T_\infty} = \frac{1}{\cosh(mL/2)}$
- 2 POINTS TO FIND $k = 50.74\ W/m^\circ C$
- 2 POINTS TO FIND $h_c = 50.35\ W/m^2{}^\circ C$