2017 Heat Transfer Midterm Exam

When is the best time for you?

Tue 18 April 8:15 -- 10:15	0
Wed 19 April 18:00 -- 20:00	0
Thu 20 April 8:15 -- 10:15	0
Fri 21 April 10:00 -- 12:00	8
Fri 21 April 16:00 -- 18:00	11
Fri 21 April 18:00 -- 20:00	11
Tue 25 April 8:15 -- 10:15	3
Wed 26 April 18:00 -- 20:00	3
Thu 27 April 8:15 -- 10:15	3
Fri 28 April 10:00 -- 12:00	7
Fri 28 April 16:00 -- 18:00	15
Fri 28 April 18:00 -- 20:00	9

Poll ended at 6:22 pm on Monday April 10th 2017. Total votes: 70. Total voters: 28.

Friday April 21st 2017
18:00 — 20:00

NO NOTES OR BOOKS;
USE HEAT TRANSFER TABLES THAT WERE DISTRIBUTED;
ANSWER ALL 4 QUESTIONS; ALL QUESTIONS HAVE EQUAL VALUE.

Question #1

The temperature distribution in a certain plane wall is

$$\frac{T-T_1}{T_2-T_1}=C_1+C_2x^2+C_3x^3$$

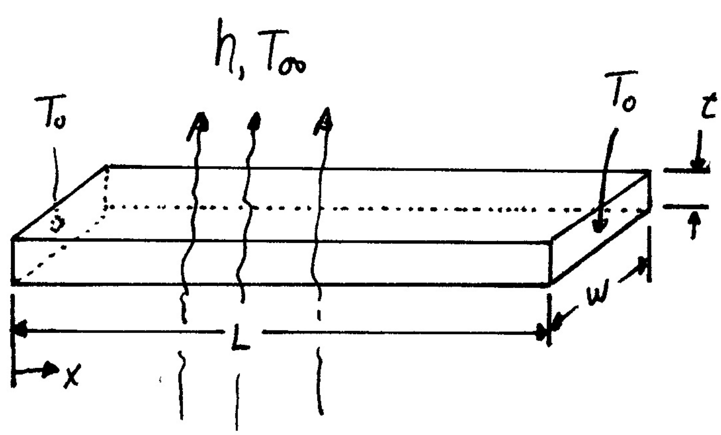
where T_1 and T_2 are the temperatures on each side of the wall. If the thermal conductivity of the wall is constant and the wall thickness is L, derive an expression for the heat generation per unit volume as a function of x, the distance from the plane where $T = T_1$. Let the heat generation be S_0 at $x = 0$.

Question #2

You are working for KAI (Korea Aerospace Industries) and are in charge of the design of the cooling system of the altimeter installed in the cockpit of the A50 fighter jet. The altimeter requires 50 Watts of power to operate and has dimensions of 10 cm $\times$ 10 cm $\times$ 10 cm. The design of the cooling system should be such that it keeps the back surface of the altimeter below 60° C while minimizing additional weight. Recalling the theory learned in your Heat Transfer course that you took several years ago at PNU, you decide to cool the altimeter by installing on its backside 10 aluminum fins with a thickness of 2 mm. The fins are rectangular, have a width equal to the one of the altimeter, and are long enough that the tips can be considered insulated. Knowing that the air behind the instrument panel is at a temperature of 20° C with an associated convective heat transfer coefficient of $h = 12\ \mathrm{W/m^2 \cdot {}^\circ C}$, find the value of the fin length that matches the design constraints. Take into consideration the fact that the convective heat transfer coefficient is not known accurately and may vary by as much as 30%.

Question #3

Consider the following fin made of copper joining two objects each with the temperature T_0:



For $W = 1$ m, $t = 0.01$ m, $L = 3$ m, and given the copper properties $c = 393$ J/kgK, $k = 386$ W/mK, $\rho = 9000\ \mathrm{kg/m^3}$, and knowing that $T_0 = 300°$C and $T_\infty = 20°$C, and that the conductive heat transfer between the fin and the objects cooled corresponds to:

$$(q_x)_{x=0} = -(q_x)_{x=L} = 1700\ \mathrm{W}$$

do the following:

(a) Find h, the convective heat transfer coefficient over all exposed surfaces of the fin.

(b) Find the fin efficiency η_{fin}.

Question #4

Consider a 0.0245m-radius sphere made in yellow-pine wood initially at a temperature of 200° C. The sphere is cooled with cold air at a temperature of $T_\infty = 20^\circ$ C and a convective heat transfer coefficient $h = 3$ W/m^{2}K. Knowing that after a time Δt, the sphere loses 13.114 kJ to the environment, do the following:

(a) Find the time elapsed, Δt, in seconds.

(b) At a time of $t = \Delta t$, find the center temperature of the sphere in Celcius.

(c) At a time of $t = \Delta t$, find the temperature on the surface of the sphere in Celcius.

Answers

1. $S_0 - \frac{3xS_0}{L} - \frac{6xk}{L^3}(T_2 - T_1)$
2. 7.9 cm.
3. 5 W/m^{2}K, 0.4.
4. 5853 s, 92° C, 76° C.