Student Code Number:_____

Ph.D. Qualifying Exam

HEAT TRANSFER
Fall 2008

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Directions: Open Book (only one book allowed) and closed notes

Answer all four questions

All questions have equal weight

Time: 3.0 hrs.

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- Take any required property from your book, approximate values if necessary.
- If you make any assumption to reach a solution state it clearly

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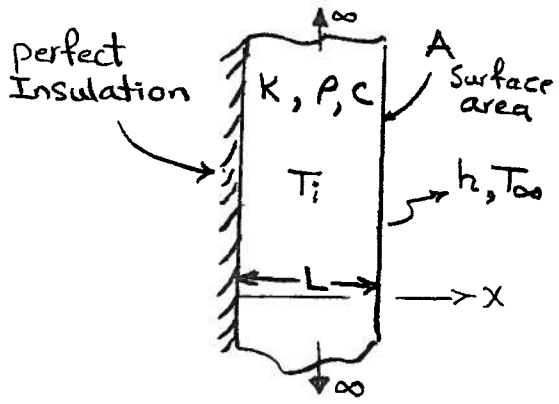
Question # 1

Consider the transient heat conduction in the following solid slab. The initial temperature of the slab is T_i and there is no heat source or sink. Answer the following questions:

(a) Derive the one-dimensional differential equation for the temperature inside the slab and write down all the required boundary/initial conditions. Assume that the thermal conductivity is a function of temperature (Hint: you may use the general form of heat conduction equation or derive the equation from a control volume analysis).

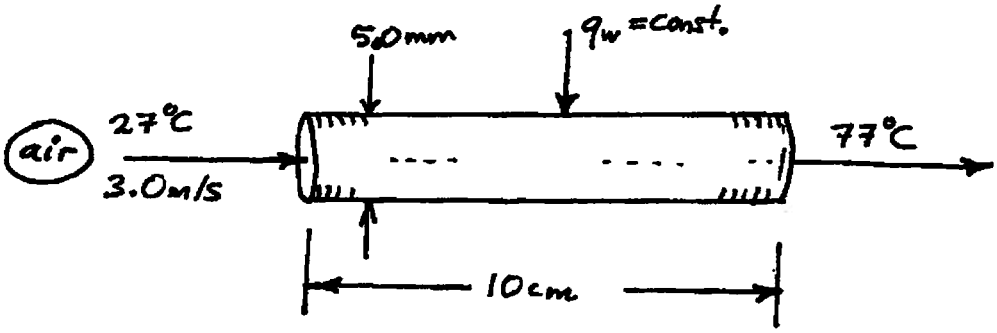
(b) The two important non-dimensional parameters for this problem are the Fourier and Biot numbers. Write down the definition of these parameters and explain the physical meaning of them. What happens when they become very large or very small?

(c) Show how you solve the equation you derived in part (a) for constant thermal conductivity coefficient (Hint: you may use separation of variable OR Laplace transform methods).



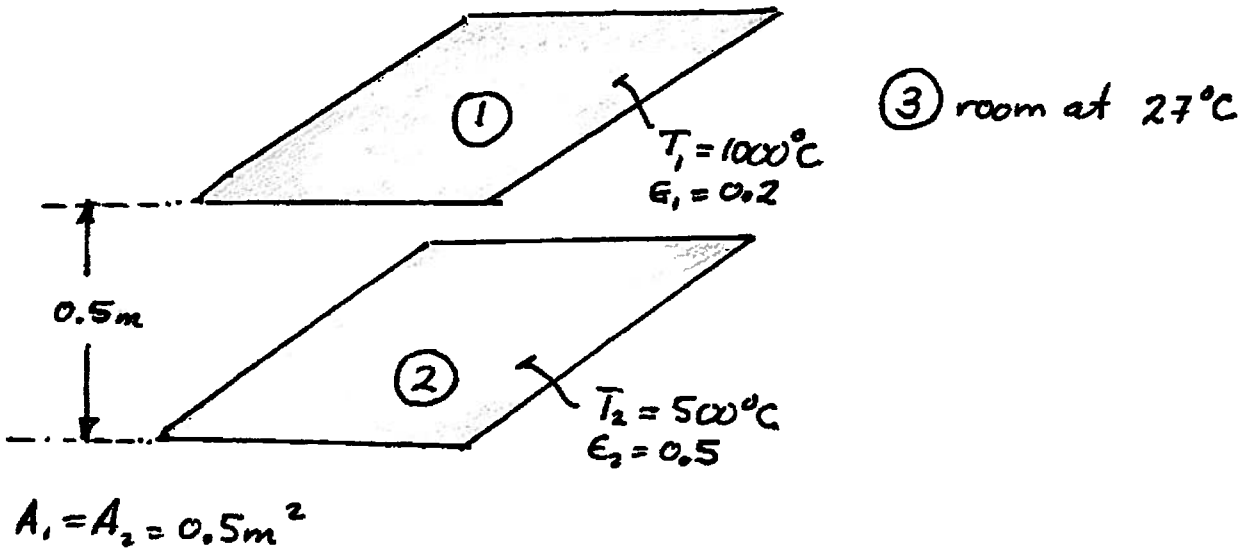
Question # 2

Air at *1 atm* and *27 °C* enters a *5.0 mm* diameter smooth tube with a velocity of *3.0 m/s*. The length of the tube is *10 cm*. A constant heat flux is imposed on the tube wall. Calculate the heat transfer if the exit bulk temperature is *77 °C*. Also calculate the exit wall temperature and the value of the convective heat transfer coefficient *h* at the exit.



Question # 3

Two parallel plates *0.5* by *1.0 m* are spaced *0.5 m* apart. One plate is maintained at *1000 °C* and the other at *500 °C*. The emissivities of the plates are *0.2* and *0.5*, respectively. The plates are located in a very large room, the walls of which are maintained at *27 °C*. The plates exchange heat with each other and with the room, but only the plate surfaces facing each other are to be considered in the analysis. Find the net transfer to each plate and to the room.



$A_1 = A_2 = 0.5m^2$

Question # 4

Consider a person (like yourself) in a cold (10°C) room as a system.

(a) Identify all mechanisms of energy transfer including the ones due to phase change at surface (skin) of this system. Apply the global (integrated) energy balance to derive a mathematical model for the skin temperature

(b) Apply the (global) integrated energy balance to derive a mathematical model for the amount of food energy (calories) needed to maintain a constant body temperature (which is normally about 37°C).

Write down all your assumptions, including those you make to simplify your analysis.