ME109 – Heat Transfer

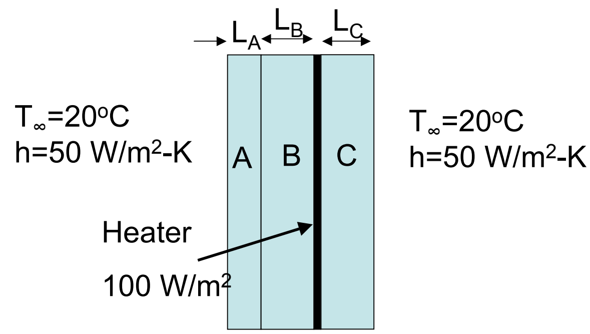
Midterm 1- Fall'04

Instructor: Prof. A. Majumdar

Oct. 19, 2004; 5:10 pm - 6:30 pm; Maximum Points = 30

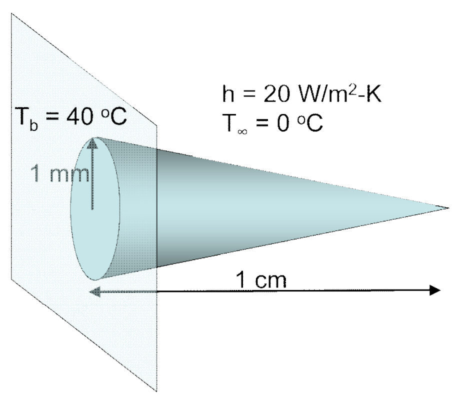
NOTE: This is an open book, open notes exam.

1. Consider a very thin planar heater surrounded by materials on both sides, as shown in the figure on the right. The heater dissipates 100 W/m^2 and it is immersed in a fluid at 20^{o}C that transfers heat with a coefficient of 50 W/m^2-K. Under steady state, determine the temperature of the heater, given the properties shown on the figure. [10]



2. You have been asked to find the steady state radial temperature distribution, *T(r),* in a long cylinder of radius, *R*. There is no heat generation and no circumferential heat flow, only radial heat flow. The cylinder is placed in a fluid of temperature, T_f, with a heat transfer coefficient of *h*. You decide to solve the problem numerically using a finite difference technique.
   a. Identify the right mesh or grid structure to determine *T(r)*. [3]
   b. Write down a nodal equation for an internal node which is not at the center. [4]
   c. How will you deal with a node at the center. [3] [10]

3. Consider a fin of conical shape extending from a wall, as shown in the figure below. The radius at the base is *R* = 1 mm, and the fin length is *L* = 1 cm. The thermal conductivity of the fin material is *k* = 10 W/m-K. The wall or the base is fixed at 40 ^{o}C. Initially the fin is initially at 40 ^{o}C, and is suddenly immersed in a fluid with heat transfer coefficient, *h* = 20 W/m^2-K and temperature of 0 ^{o}C.



   a. Consider the appropriate control volume and derive a governing equation for the temperature distribution and evolution of the fin. Solve the equation to determine the temperature distribution and history. [4]
   b. What is the effectiveness of the fin under steady state? [3]
   c. What is the efficiency of the fin under steady state? [3] [10]

Note: The surface area of the slanting surface (i.e. without the base) of the cone is π*RL*, where *R* is the base radius and *L* is the length.