MEAM 333: Heat and Mass Transfer
Assignment 6
Due Date: 2/7/2012

Homework Guidelines:

- All papers must be stapled (No dog eared pages!).
- Solutions must proceed in a step-by-step fashion so that it is easy for the grader to follow and the method is well explained.
- Handwriting should be neat and presentation should be professional.
- Final answers for each part should be boxed or double underlined.
- Failure to do the above will result in point deductions.

Problem 1 [Solution]:

A 0.2 m diameter thin walled steel pipe is used to transport saturated steam at a pressure of 20 bars in a room for which the air temperature is 25°C and the convection heat transfer coefficient at the outer surface of the pipe is 20 W/m^2K.

a. What is the heat loss per unit length from the bare pipe (no insulation)? Estimate the heat loss per unit length if a 50 m thick layer of insulation (magnesia, 85%) is added. The steel and magnesia may each be assumed to have an emissivity of 0.8, and the steam-side convection resistance may be neglected.
b. The costs associated with generating the steam and installing the insulation are known to be \$4 per 10^9 J generated and \$100 per meter of pipe length, respectively. If the steam line is to operate 7500 hours per year, how many years are needed to pay back the initial investment in insulation?

Problem 2 [Solution]:

Approximately 10^6 discrete electrical components can be placed on a single integrated circuit (chip), with electrical heat dissipation as high as 31,000 W/m^2. The chip, which is very thin, is exposed to a dielectric liquid at its outer surface, with h_o = 950 W/m^2-K and $T_{\infty,o}$ = 21°C, and is joined to a circuit board at its inner surface. The thermal contact resistance between the chip and the board is 10^{-4} m^2 K/W, and the board thickness and thermal conductivity are L_b = 4 mm and k_b = 1.22 W/m-K, respectively. The other surface of the board is exposed to ambient air for which h_i = 30 W/m^2K and $T_{\infty,i}$ = 20°C.

1. Sketch the equivalent thermal circuit corresponding to steady-state conditions. In variable form, label appropriate resistances, temperatures, and heat fluxes.
2. Under steady-state conditions for which the chip heat dissipation is q_c'' = 30,000 W/m^2, what is the chip temperature?