Code Number :.............

HEAT TRANSFER QUALIFYING EXAM

January 2010

OPEN BOOK (only one book allowed)

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

Water enters a circular tube at 10 °C and is to be heated to 45 °C in a tube of 0.025 m inside diameter at a mass flow rate of 0.02 kg/s. The outside of the tube is wrapped with an insulated heating element that produces a uniform flux of 20,000 W/m^2 over the surface. Neglecting any entrance effects, find

a) The Reynolds number (state at what temperature you estimate the properties)
b) The heat transfer coefficient
c) The length of pipe needed for a 35 °C increase in mean temperature
d) The inner tube surface temperature at the outlet
e) The friction factor
f) The pressure drop in the pipe
g) The pumping power required if the pump is 60% efficient.
h) The current need for an electrical supply of 120V.

Question # 2

A very long tube of 0.05 m diameter is maintained at 110 °C (through steam passing at its center). A radiation shield is installed around the tube with an air gap of 20mm. If the shield is at 40 °C, estimate the heat transfer per unit length by radiation and convection between the two surfaces, i.e. what is the heat transfer through the gap (assume that both surfaces have an emissivity of 0.9). How would the rate of heat transfer per unit length changes if the gap were filled with a glass-fiber blanket (k = 0.038W/mK)?

Question # 3

A plane wall of AISI 301 stainless steel extends from 0 to L in the x-direction and is semi-infinite in the y-direction. At x=0 and x=L, the plate is at a uniform temperature of 50 °C. At y=0, the temperature is uniform at 100 °C. The boundaries are uniform in the z-direction. Solve for the steady state temperature profile.

a) Draw the wall and label the appropriate boundary conditions.
b) Write the governing equation and boundary conditions.
c) Transform the temperature to get homogeneous boundary, conditions as appropriate.
d) Solve for the steady state temperature profile in the wall using separation of variables.

Question # 4

The floor of a cubical room (3 m x 3 m x 3 m) has an emissivity of 0.8 and is heated to maintain its temperature at 30 °C. Each wall also has emissivity of 0.8 and is perfectly insulated. There is no ceiling. Instead the room is open to the night sky at -40 °C.

a) Calculate the temperature of the walls.
b) Calculate the power needed to maintain the temperature of the floor.