Heat Transfer (ME30005), Mid Semester Examination, September 2012, time-2 hours, Full Marks-60

Q1.

(a)

Starting from Reynolds Transport theorem, derive a governing differential equation for the variation of kinetic energy of an ideal fluid. Also derive a governing differential equation for the total energy of the same fluid. Hence, obtain a governing differential equation for the internal energy of the fluid. State the assumptions that you make.

(b)

State the major assumptions/ restrictions under which the following expressions are valid (symbols have usual meaning as discussed in the class):

(i) $-k\left.\frac{\partial T_{\text{solid}}}{\partial n}\right|_{\text{interface}} = h\left(T_{\text{solid}} - T_{\infty}\right)$, where n is a directional normal to the interface that is directed towards the fluid away from the solid across a fluid-solid interface and $\frac{\partial T_{\text{solid}}}{\partial n}$ refers to the temperature gradient calculated on the basis of the temperature profile in the solid.

(ii) $C_{ijkl} = C_{jikl}$ (where $\tau_{ij}^{\text{deviatoric}} = C_{jikl} e_{kl}$)

[16+4 = 20 Marks]

Q2.

(a)

(i) Write the thermal boundary layer equation for steady flow with constant properties. What are the major assumptions under which this equation is valid?

(ii) By order of magnitude analysis, derive a scale for the ratio of the transverse velocity components at the edges of the hydrodynamic boundary layer and the thermal boundary layer respectively, for Pr>>1.

(b)

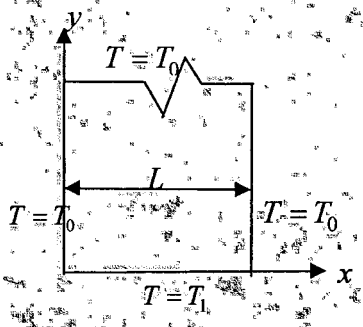
A person is found dead at 5 pm in a room whose temperature is 20°C. The temperature of the body is measured to be 25°C when found, and the heat transfer coefficient between the body and its ambient is 8W/m^2.K. In an effort to estimate the time at which the person died, an investigator models the body as a 30-cm diameter, 1.7-m-long cylinder, with a uniform temperature. Based on this, estimate the time at which the person died. Consider that the temperature of the body was 37°C, when the person died. Mention the assumptions behind your analysis clearly, and criticize on the validity of some important assumption concerned.

[13 + 7 = 20 Marks]

Please turn over

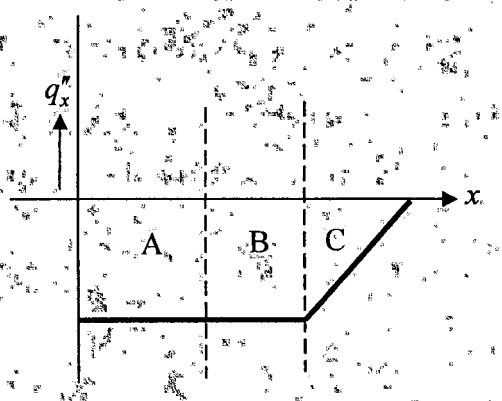
Q3.

(a)



Consider an infinitely long (in y-direction), thin rectangular plate as shown in the figure. Obtain the temperature distribution within the plate as a function of (x, y).

(b)



In a composite material A-B-C (respective thermal conductivities are related as: $k_A < k_B$; $k_B > k_C$), the steady state heat flux distribution is as shown in the figure. Sketch the corresponding steady state temperature distributions (no credit will be given without justification of proper logic behind your sketch).

[14+6 = 20 Marks]