Ref. No. Ex/PG/ME/T/1210E/2024

M. E. NUCLEAR ENGINEERING FIRST YEAR SECOND SEMESTER EXAMINATION 2024

MICRO SCALE HEAT TRANSFER

Time: 3 Hours **Full Marks: 100**

Answer question 1 and any three from rest. Assume any unfurnished data suitably.

1. Write a short note on a) Thermal creep phenomenon, (b) Accommodation Coefficient. (10)

2. Consider Poiseuille flow between two infinitely long plates, maintained at different temperatures. Find out the temperature inversion condition assuming second order slip velocity boundary condition and first order temperature jump boundary condition. (30)

3. Consider incompressible flow through a micro-channel of a separation distance of L. The upper and lower plates are kept at temperatures T_1 and T_0 respectively ($T_1 > T_0$). The upper plate is moving with a uniform velocity U and the lower plate is stationary. Derive the velocity and temperature profile considering first order model of slip velocity (consider slip velocity as a function of normal velocity gradient and thermal creep). Also find out the condition for temperature inversion. (30)

4. State the significance of the correction term added by Cattaneo-Vernotte on Fourier law of heat conduction. From Cattaneo-Vernotte equation, deduce the hyperbolic heat conduction equation. Comment on the role of the relaxation time used in the equation. With the help of scaling analysis, show the regime where the hyperbolic term will be important. (30)

5. Derive the Poisson-Boltzmann equation for potential distribution for a semi-infinite electrolyte medium. Write a note on Debye-Huckel approximation. (30)

6. Deduce the fully developed axial momentum equation for electro-osmotic flow (without pressure gradient) through a channel. Solve your derived equation with suitable boundary conditions. Assume $\cosh(x) = 1+x^2/2!$. (30)