Ref. No. Ex/PG/ME/T/1210E/2019

MASTER OF NUCLEAR ENGINEERING FIRST YEAR EXAMINATION 2019

(Second Semester)

MICRO-SCALE HEAT TRANSFER

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

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

1. Show that a rarefied fluid can creep from cold to hot end due to tangential temperature gradient along the channel walls. (10)

2. Consider fully developed flow through a gap L between two plates. The upper plate is moving with a velocity U along its length. Find out the velocity profile, temperature profile and temperature inversion condition considering first order slip velocity model and temperature jump boundary condition. Assume T_1 and T_0 temperatures for the two plates. (30)

3. Consider Poiseuille flow in a micro channel of width 2L. The walls are kept at temperatures T_1 and T_2 ($T_1>T_2$). Find out the Nusselt number assuming second order slip velocity at the walls. The temperature jump at the walls could be neglected. Also find out the condition of temperature inversion, if any, for such a flow. (30)

4. Deduce the hyperbolic conduction equation. Comment on the role of the relaxation time used in the equation. State the condition for which hyperbolic conduction equation will be reduced to standard conduction equation. Show that the hyperbolic term will play an important role in case of a nano-sized domain. (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. A constant electric field E is applied along the axial direction of a micro-channel. Deduce the fully developed axial momentum equation for electro-osmotic flow without pressure gradient for the channel. Solve for the derived equation assuming suitable approximation. (30)