Ref. No. Ex/PG/ME/T/1210E/2018

M.E. MECHANICAL ENGINEERING FIRST YEAR EXAMINATION 2018

(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. Write a short note on a) Tangential Momentum Accommodation Coefficient, (b) Knudsen Compressor. (10)

2. Consider fully developed flow through a gap L between two plates, moving at velocities U and –U respectively along their lengths. Find out the velocity profile, temperature profile and expression for Nusselt number 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. 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. What do you understand by Electric double layer? Show that the charge distribution can be expressed with the help of Boltzmann distribution in presence of EDL. Deduce the Poisson-Boltzmann equation for potential distribution in a stationary fluid. (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)