Name: BITS ID:

BITS Pilani, Pilani campus

Mid-semester examination, Second semester 2021-2022

ME F423 Microfluidics and it's applications

Total marks: 25, Weightage: 25%, and Date & Time: 11/03/2022 & 9:00 am to 10:30 am.

(i) It's an open book examination but the textbook/reference books as per the course handout, class slides, and hand written notes are only permitted. (ii) Assume any missing data and state the assumptions if any.

Questions

Q1. What is Microfluidics and why is it so important? Also, could you name any four applications of Microfluidics? [3 marks]

Q2. What do you understand by continuum assumption in fluid mechanics? When does the above assumption fail and how does it affect the solution methodologies in Microfluidics? [3 marks]

Q3. What are newtonian and non-newtonian fluids? Give one example for each of them and how do you mathematically model their viscosities? [3 marks]

Q4. The number of possible interactions between N numbers of molecules in MD simulations with the L-J potential, scales approximately with N^2 and this makes MD simulations computationally very costly. One solution to this problem is to shift the potential by a function linear in r, such that the force at some cutoff distance r_c is zero. For a case of Ar gas, could you suggest a value for r_c correspond to the 2% of the maximum value of attractive force? Also, comment on how does it help to save the computational cost. [5 marks]

Q5. Consider a flow of diatomic nitrogen N_2 at 300 K and 1 bar at a speed of 100 m/s through a two-dimensional slot measuring 0.5 mm in height and infinite in depth. Classify the type of flow you will have based on these parameters and how you would solve this problem. Calculate the slip velocity at the wall using (a) Maxwell's and (b) Sreekanth's Slip models. Also, comment on the difference in the values of slip velocities obtained. [5 marks]

Q6. A typical example for planar Couette flow is a flow generated in a fluid confined between two parallel plates of gap H by moving the upper plate at a constant velocity U. In a typical planar Poiseuille flow, the fluid is driven through a long, straight, and rigid channel formed by two parallel plates of gap H, by imposing a pressure difference Δp between the two ends of the channel. Now, consider a combined Poiseuille and Couette flow by applying a pressure difference Δp over a section of length L in the x direction for a planar Couette flow. Assuming a steady, incompressible, laminar, and fully developed flow of Newtonian fluid, derive expressions for the velocity field, the volume flow rate, and skin friction coefficient. [6 marks]