

(1) Answer the questions following the table format in your answer sheet.

[30 points]

Flow	Meanings	Example
Laminar flow		
Creeping flow		
Potential flow		
Unsteady flow		
Inviscid flow		
Compressible flow		

(2) Answer the following questions. [20 points]

- Physical meaning of  $\nabla p$  and  $\nabla p = 0$ , where  $p$  is a scalar field.
- What is Bernoulli equation? Under what conditions, the Bernoulli equation can be used?
- Why one needs two subscripts to describe a shear stress  $\tau_{xy}$ ?
- Why viscosity of liquid decreases as temperature increases?

- (3) Utilize the concept of 'diffusion' to roughly estimate the entrance lengths for (1) temperature and (2) concentration profiles to fully develop in a steady pipe flow (the wall being slightly dissolvable) with an average volumetric flow rate  $Q$  and a tube diameter  $d$ . Assume all material properties can be known. [20 points]
- (4) Briefly answer the following questions:
- Contrast free and forced convections in a thermal transport process. What are the essential dimensionless groups to be considered in each case? [10 points]
  - Explain the significance and utilization of "operating line" and "equilibrium line" in modeling a distillation tower. [10 points]
  - What are the essential factors that may affect the interfacial heat or mass transfer coefficient? Why knowledge of the values of these transfer coefficients may greatly simplify the analysis in a practical application that could otherwise be very complex to solve? [10 points]