M. CHEM ENGG. 1ST. SEM. EXAM. - 2017

ADVANCED TRANSPORT PHENOMENA

Time: three hour

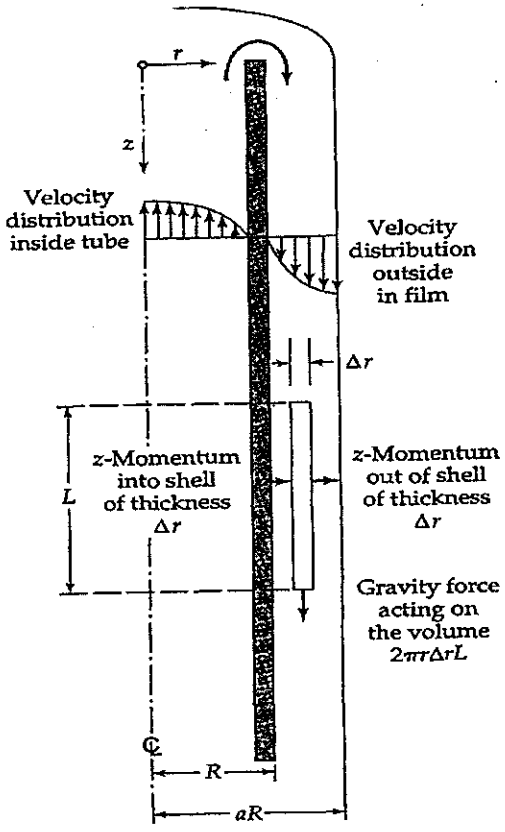
Full marks: 100

Answer any five questions
Assume any missing data
All questions carry equal marks
Symbols have usual significance
Draw labeled schematic of the problem wherever needed
Clearly state all the assumptions, boundary and initial conditions

1) Derive x-component of equation of motion in Cartesian coordinate system. Show that the equation of motion may be arranged for three-dimensional case as

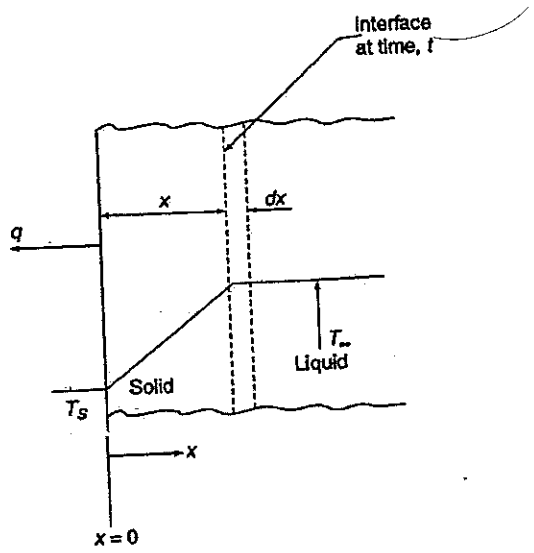
$$\rho \frac{DV}{Dt} = -\Delta P + \Delta \tau + \rho g$$

2)



According to the associated figure, derive the velocity profile of the falling film. Find the expression of average velocity and shear stress on the wall. Find an expression for Reynolds number of the falling film. Mathematically show that between up flow and down flow streams continuity equation is satisfied,

3)



In the above figure, schematic of a solidification (moving boundary) problem is presented. In this problem liquid is being solidified. Derive a relation between the thickness of solid section as a function of time. Write proper assumptions and boundary conditions required to solve the problem.

4) Derive momentum boundary layer equation from Navier-Stokes equations by order of magnitude analysis. Why it is called two dimensional boundary layer? How boundary layer separation occurs.

5) Derive velocity and temperature distributions in non-isothermal Couette flow. Explain the significance of Brinkman number on heat transfer to the boundary plates.

6) A solid A is dissolving in a flowing liquid stream S under steady isothermal condition. According to film theory a liquid film of thickness Δ prevails on the solid surface. Outside the liquid film well mixed condition prevails. Derive an expression for dissolution rate of solid in the liquid if concentration of A in bulk of the liquid is negligible. Also derive expression for dissolution rate of A in the liquid if A undergoes an instantaneous irreversible reaction with a substrate B in the liquid. Assume the reaction plane is at kΔ away from the solid surface and in the liquid film. Also show that rate of dissolution is enhanced by the chemical reaction.

7) Gas mixture of A and B flowing over a catalyst surface forming a film of thickness L. A diffuses through the film and reacts on the catalyst surface. The product diffuses back to the main gas stream. Derive expression for concentration distribution of A in the film. Identify the limiting conditions when diffusion and chemical reaction is controlling and its effect on concentration distribution and flux at the catalyst surface.