1.(20%)

(a) What is the physical meaning of the equation of continuity? Please write down the equations of continuity for incompressible flow and compressible flow, respectively.

(b) Name any three distinct methods that can be used in measuring the volumetric flow rates. You have to describe the principle for each measuring method.

2.(15%)

Determine $v_\theta(r)$ between two coaxial cylinders of radii R and κR rotating at angular velocities Ω_o and Ω_i, respectively. Assume that the space between cylinders is filled with an incompressible isothermal fluid in laminar flow.

3.(15%)

A metal sphere of radius r_0 and thermal conductivity k is initially in equilibrium at $400^\circ C$ in a furnace. It is suddenly removed from the furnace and cooling in air at $20^\circ C$. The convection heat transfer coefficient for this cooling process is h.

(a) Write the conservation equation of the transient conduction occurs in the sphere.

(b) What are the initial and boundary conditions?

(c) Under what physical condition the temperature in the sphere can be regarded as uniform?

4. (15%)

Steam condensing on the outer surface of a thin-walled circular tube of 50 mm diameter and 6m length maintains a uniform surface temperature of $100^\circ C$. Water flows through the tube at a rate of $\dot{m} = 0.25 kg/s$, and its inlet and outlet temperatures are $T_{m,i} = 15^\circ C$ and $T_{m,o} = 57^\circ C$, respectively ($c_p = 4178 J/kg \cdot K$ for water at $36^\circ C$).

(a)What is the total heat transfer rate of this tube?

(b)What is the log mean temperature difference of this system?

(c)What is the average convection coefficient associated with the water flow?

5.(20%)

Air containing a water-soluble vapor is flowing up and water is flowing down in the experimental column shown in the following figure. The water flow in the 0.07-cm-thick film is 3 cm/sec, the column diameter is 10 cm, and the air is essentially well mixed right up to the interface. The diffusion coefficient in water of the adsorbed vapor is $D=1.8\times10^{-5}$ cm^2/sec. How long a column is needed to reach a gas concentration in water that is 10% of saturation ?

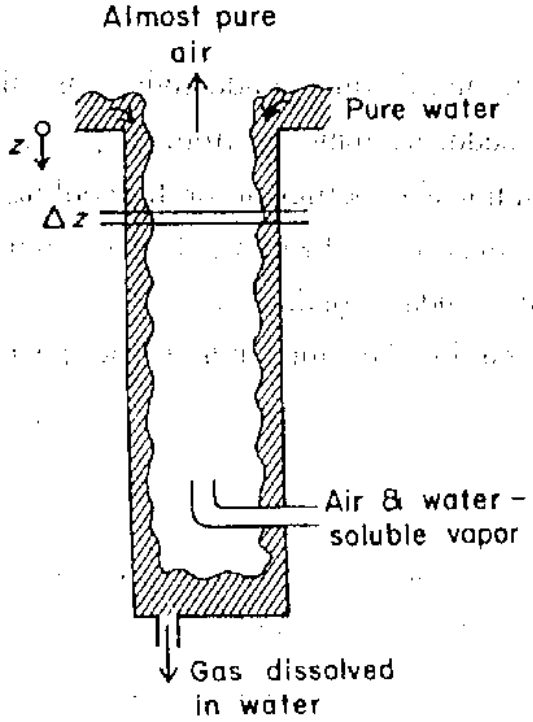
Hint:1. Write a mass balance on the water in a differential column height Δz.

2. The entering water is pure.

3. The correlation of mass transfer coefficient (k) for falling films is given by

$$kz/D = 0.69\ (zv^0/D)^{1/2}$$

where z = position along film, v = average film velocity



6.(15%)

A spherical particle is suspended in a liquid. The sphere is of a sparingly soluble material, so that the sphere's size does not change much. However, this material quickly dissolves in the surrounding solvent, so that the solute's concentration at the sphere's surface is saturated (c_1(sat)). Because the sphere is immersed in a very large fluid volume, the concentration far from the sphere is zero.

The goal is to find both (a) the concentration profile around the sphere and the dissolution flux. (b)If the sphere is twice as large, what are the dissolution flux and the total dissolution rate?

Hint: 1. Write the mass balance in spherical coordinates.

2. The dissolution flux is the dissolution rate per unit area.