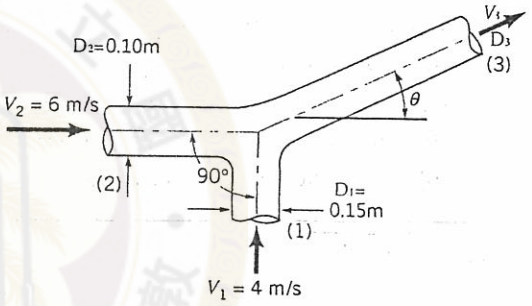
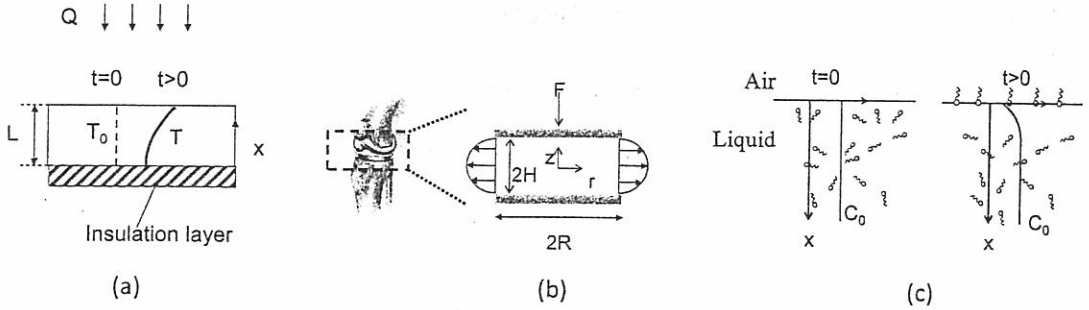
1. Please briefly answer the following questions.
   (a) What is the definition and physical meaning of Schmidt number? (3%) If Schmidt number of air has its value close to 10^N, and here N is an integer. What will N be based on the physical meaning of Schmidt number?(2%)
   (b) What is the physical meaning of shear stress τ_{yx}? Please explain it in terms of force (3%) and momentum flux (2%)
   (c) The drag coefficient C_D for fluid passing a sphere drops dramatically at Reynolds number around 3×10^5. Please explain the cause of this change in C_D. (5%)

2. Two water jets collide and combine to one homogenous jet as shown in the figure below. For simplicity, we assume that the jets are cylindrical and the gravity force applied on the jets is **negligible**. Note that the jets are surrounded by air, and the gauge pressure at all jets is 0. Please answer the following questions using the macroscopic balance:
   (a) Write down the mass balance equation. Simplify it using the given conditions. (3%)
   (b) Write down the linear momentum balance equations. Simplify them using the given conditions. (6 %)
   (c) Use the results of (b) to determine the angle θ of the combined jet. (3 %)
   (d) Determine the speed of the combine jet V_3. (3 %)
   (e) Determine the friction loss of this system. (5 %)



3. A flat slab of thickness L is used in a greenhouse as a heat source in the night. In the day, sunlight gives a constant heat flux Q at the slab surface (Figure (a)). The bottom layer under the greenhouse is a well-insulated foam material.
   (a) Write down the governing equation, initial condition, and boundary conditions for temperature in the slab. (5%)
   (b) Define the average temperature of the metal plate as $\theta \equiv \int_0^L T dx / L$, determine the governing equation and initial condition for θ from the previous equation set. (5%)
   (c) Find the average plate temperature θ as a function of time. (5%)



見背面

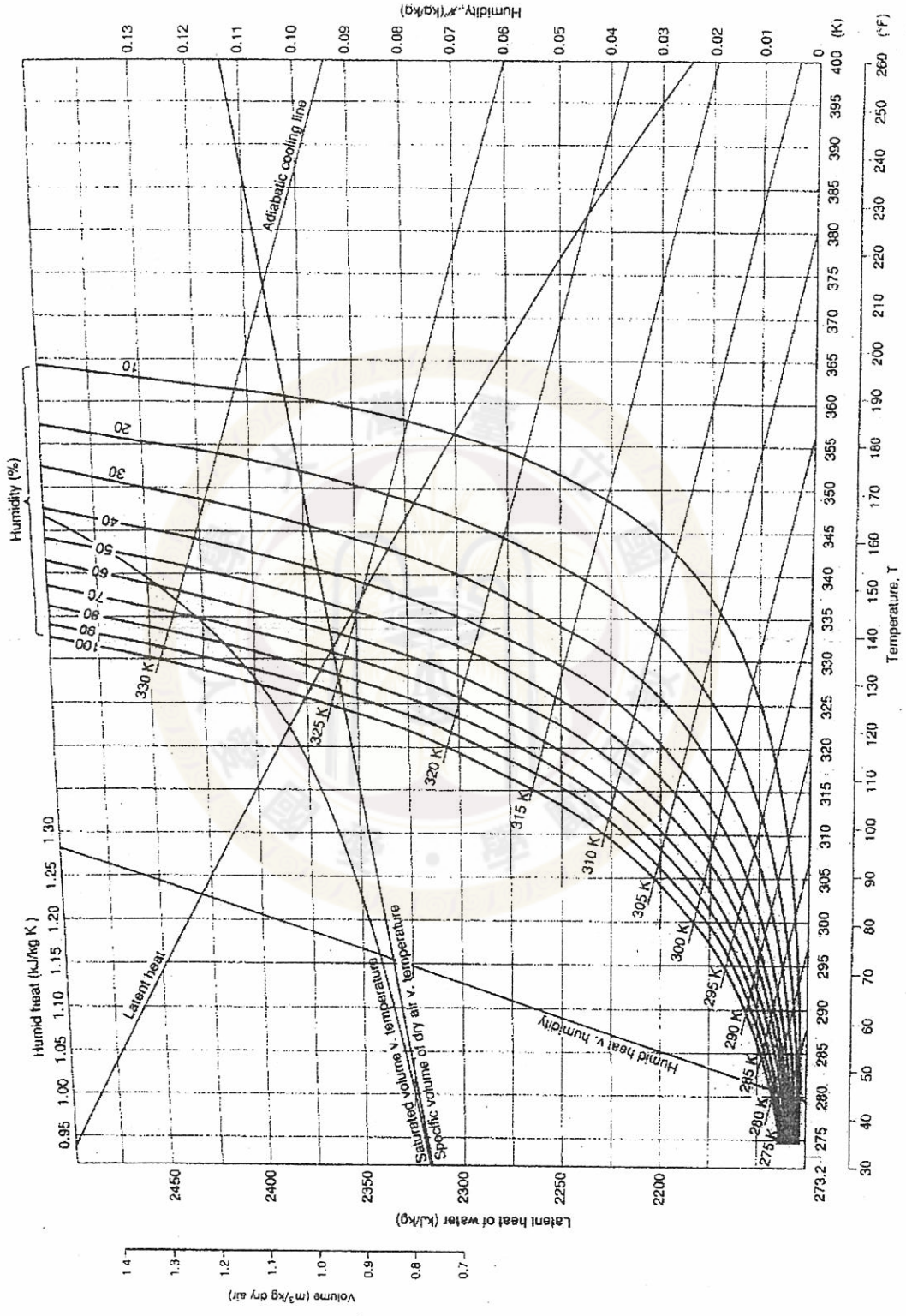
4. A patient stands up and puts all his weight on his feet. The knees feel and absorb the pressure. Then, the lubricating fluid film thickness reduced in his knee joint. We want to estimate how fast the bones are brought together. One engineer approximates the joint as two parallel circular plates with fluid filled in between (see Figure (b)). He further assumes that the incompressible fluid follows a pseudo-steady-state laminar flow in r-direction. Determine the gap size H as a function of time *t* if a constant force F is applied. (15%)

5. A dilute aqueous surfactant solution of concentration C_0 (mol/m^3) was put in a large beaker for a while. One graduate student quickly aspirated the surface so that the surface is free of surfactant molecules without disturbing the bulk liquid (see Figure (c)). The surfactant molecules then started to adsorb onto the interface and the resulting transient surface tension reduction was then monitored.
   (a) Write down the transient mass transfer equation for surfactant molecules in the static bulk liquid. (2%)
   (b) The surfactant adsorbed onto the surface and accumulated as a thin monolayer with surface density Γ (mol/m^2). Apply mass balance at the air/water interface (or the monolayer) and obtain the interfacial boundary condition. (3%)
   (c) Complete the equation set with proper initial and boundary conditions for surfactant concentration in the bulk liquid assuming that the surfactant concentration far away is unaffected. (3%)
   (d) Is your equation set able to describe the system? (2%)

6. A particle suspension solution was put to settle. The sedimentation velocity of the particles is $v_c = v_0\varepsilon^n$, where v_0 is a constant and ε is the volume fraction of liquid solvent. Determine the maximum particle mass flux and the corresponding solid fraction. (10%)

7. For a certain process requiring air at controlled temperature and humidity there is needed 6000 kg of dry air per hour at 20% humidity and 328K. This air is to be obtained by conditioning air at 10% humidity and 300K by first heating, then humidifying adiabatically to the desired humidity, and finally reheating the humidified air to 328K. The humidifying step is to be conducted in a spray chamber. Assuming the air leaving the spray chamber is at the adiabatic-saturation temperature, please use the humidity-temperature chart to answer to following questions.
   (a) To what temperature should the air be preheated? (2 %)
   (b) What is the temperature of air when it leaves the spray chamber? (2 %)
   (c) How much heat will be required for preheating? (3 %)
   (d) How much heat will be required for reheating? (3 %)
   (e) What is the humid volume of air after reheating? (5%)

接次頁


Humidity, χ (kg/kg)
Adiabatic cooling line
Humidity (%)
Humid heat (kJ/kg K)
Latent heat
Saturated volume v. temperature
Specific volume of dry air v. temperature
Humid heat v. humidity
Latent heat of water (kJ/kg)
Temperature, T
Volume (m³/kg dry air)

試題隨卷繳回