Mansoura University
Faculty of Engineering
Mechanical Power Eng. Dept

3rd Year of Mechanical power Eng.
Time Allowed: 3 hour
Computer Application in MPE III

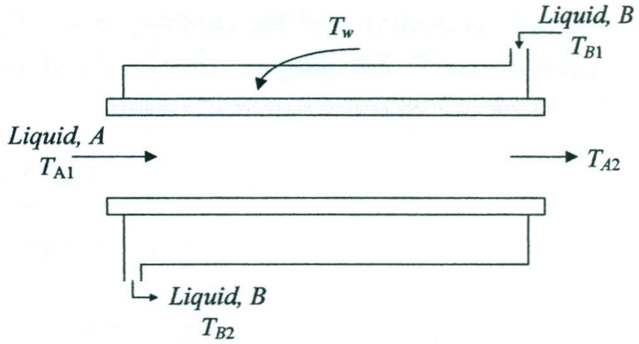
Final Exam, Jan. 2013

Answer the following questions, and assume any missing data:

Q1. *Fundamentals* [15 mark]

a) State the steps of the general procedure for building up a mathematical model. [5 mark]

b) Develop the lumped model (state the assumptions clearly) and make the degree of freedom analysis for a system of a tube heat exchanger shown in the figure. Liquid A of density ρ_A and specific heat c_{pA} is flowing through the inner tube and is being heated from temperature T_{A1} to T_{A2} by liquid B of density ρ_B and specific heat c_{pB} flowing counter-currently around the tube. The temperature of liquid B decreases from T_{B1} to T_{B2}. [10 mark]



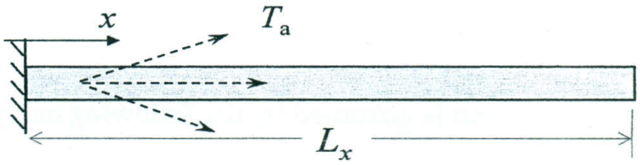
Q2 *ODE* [20 mark]

The conservation of heat can be used to develop a heat balance for a long, thin rod. If the rod has a uniform heat generation and is not insulated along its length and the system is at steady state. The equation that results is:

$$\frac{d^2T}{dx^2} = h(T - T_a) + S$$

with boundary conditions

$$T(0) = T_0, \quad \text{and} \quad \left.\frac{dT}{dx}\right|_{x=0} = q$$



where h is a heat transfer coefficient (m^{-2}) that parameterizes the rate of heat dissipation to the surrounding air, T_a is the temperature of the surrounding air (°C), and S is the heat source (°C /m²).

Take: L_x =1.0 m, T_0 = 20 C, q =20 C/m, h =0.025 m^{-2}, T_a =20C, and S =20 C/m²

a) By hand calculation, using Euler method calculate the temperature distribution along the fin, take step size $\Delta x = 1/3$ m. [5 mark]

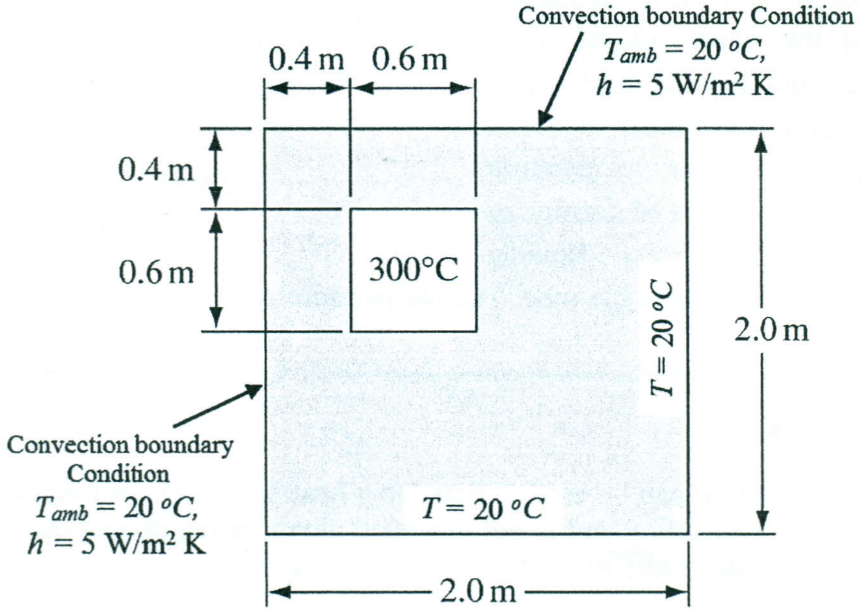
b) Write a MATLAB function to solve a system of ordinary differential equations by Euler method. [5 mark]

c) Write a MATLAB function to define the model and its parameters and constants. [5 mark]

d) Write a MATLAB script to solve for the temperature distribution in the fin described above. [5 mark]

Q3 *PDE* [25 mark]

The horizontal cross section of an industrial chimney is shown in the accompanying sketch. Flue gases maintain the interior surface of the chimney at 300 °C, and the outside northern and western surfaces are exposed to an ambient temperature of 20 °C through a heat transfer coefficient of 5 W/m^2 K, while the southern and eastern surfaces are maintained at 20 °C. The thermal conductivity of the chimney is k = 0.5 W/m K, the density ρ= 1800 kg/m^3, and the specific heat c = 840 J/kg K. initially, the chimney is at temperature of 20 °C.



If the system is governed by the following energy (unsteady conduction) equation

$$\frac{\partial T}{\partial t} = \alpha\left(\frac{\partial^2 T}{\partial x^2} + \frac{\partial^2 T}{\partial y^2}\right)$$

a) Derive the finite difference equations (FDE) and the stability conditions for:
   i. The interior (non-boundary) nodes [3 mark]
   ii. The boundary nodes [7 mark]

b) Develop MATLAB code to determine:
   i. How much time is required to reach the steady state, [5 mark]
   ii. The temperature distribution in the chimney at any time, and [5 mark]
   iii. The rate of heat loss from the flue gases per unit length of the chimney at steady state. [5 mark]

Good luck,
Dr. Hossam S.S. AbdelMeguid