Mansoura University Faculty of Engineering Dept. of Power Mech. Eng. Course Title: 3D Modeling & Simulation of Heat Transfer & Fluid Flow Course Code: MPE371		BME Level 300 January 2017 Exam Type: Final Time: 2 Hours Full Mark: 50

Attempt All Questions. Assume Any Missing Data. Questions Are Equal Weight But Are Not Equal Difficulty.

Question (1)

1.a Mention the names of three conservation laws.

1.b Mention the names of two forces in the definition of Reynolds number (Re).

1.c Mention the names of two different methods used to solve the differential equations.

1.d What is the difference between Laplace equation & Poisson equation? What is the type of these partial differential equations (PDEs)? Why?

Question (2)

The velocity distribution for the flow of a Newtonian fluid between two wide, parallel plates as shown in Figure 1 can be modeled using the equation

$$\frac{\partial^2 u}{\partial y^2} = \frac{1}{\mu}\frac{\partial P}{\partial x}$$

The maximum velocity occurs at centerline (y = 0). The bottom (y = –h) and top (y = +h) walls of the plate are kept at zero velocity.

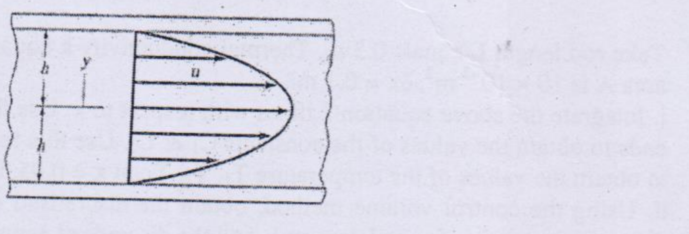
i. Integrate the above equation 2 times with respect to y. Use the 2 boundary conditions at centerline and at the bottom wall to obtain the values of the C_1 & C_2.

ii. Use this velocity distribution equation to obtain the expression of the maximum velocity.

iii. Determine the volumetric flow rate (Q). Take the plate width = b.

iv. Determine the mean velocity (V).

v. Obtain the velocity distribution equation as a function of the following parameters: the mean velocity (V), the half plate height (h), and the y-axis.



Question (3)

For the following velocity distribution.

$$u/U_\infty = a + b\eta + c\eta^2$$

Where a, b, c are constants and $\eta = y/\delta$

i. Write the three boundary conditions required to determine the constants a, b, c.

ii. By solving these three equations, obtain the values of constants a, b, c.

iii. Calculate the displacement thickness and momentum thickness in terms of δ.

Question (4)

Consider the steady-state temperature distribution for a long, thin rod positioned between two constant-temperature walls. The rod's cross sectional dimensions are small enough so that radial temperature gradients are minimal and, consequently, temperature is a function exclusively of the axial coordinate x. Heat is transferred along the rod's longitudinal axis by conduction and between the rod and the surrounding gas by convection. Radiation is assumed to be negligible. Using a heat balance for a differential element of a heated rod subject to conduction and convection, the differential equation can be expressed as

$$\frac{d^2T}{dx^2} + h'(T_\infty - T) = 0$$

where h' = a bulk heat-transfer parameter reflecting the relative impacts of convection and conduction = 2h/(rk).

i. Obtain the units of h' in 2 different ways.

ii. Show that

$$\frac{d^2T}{dx^2} \cong \frac{T_{i+1} - 2T_i + T_{i-1}}{\Delta x^2}$$

iii. Use the finite-difference approach to get the 4 x 4 matrix for a 10-m rod with h' = 0.01, T_∞ = 20°C, and the boundary conditions: T (0) = 40°C, T (10) = 200°C. Use four interior nodes with a segment length of Δx = 2 m.

Question (5)

Consider the problem of source-free heat conduction in an insulated rod whose ends are maintained at constant temperatures of T_0 = 100°C and T_4 = 340°C respectively. The one-dimensional problem is governed

$$\frac{d}{dx}\left(k\frac{dT}{dx}\right) = 0$$

Take rod length L equals 0.3 m, Thermal conductivity k equals 1000 W/m.K, cross-sectional area A is 10×10^{-3} m^2, δx = 0.1 m.

i. Integrate the above equation 2 times with respect to x. Use the 2 boundary conditions at rod ends to obtain the values of the constants C_1 & C_2. Use this temperature distribution equation to obtain the values of the temperature T_1, T_2, T_3, at x = 0.05, 0.15, 0.25 m respectively.

ii. Using the control volume method, obtain the discretised equation for nodal point 2, the discretised equation for nodal point 1, and the discretised equation for nodal point 3.

Good Luck

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