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 2019 Exam Type: Final Time: 2 Hours Full Mark: 50

Attempt All Five 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 Write an example for ordinary differential equation (ODE) in fluid mechanics.

1.c Write the Fourier's law of heat conduction. Why do we put the negative sign in the Fourier's law of heat conduction?. When does the heat flux (q) equal zero?

1.d For one-dimensional transient (unsteady) heat conduction, what is the type of this partial differential equation (PDE)? Why? What are the name & units of property (α) in this equation?

Question (2)

2.a An incompressible steady-flow pattern is given by $u = x^3 + 2z^2$ and $w = y^3 - 2yz$. What is the most general form of the third component, v(x, y, z), which satisfies continuity?

2.b Mention the names of different forces in the momentum equation.

2.c. When does the gravitational force has a value in the momentum equation?. When is this value positive?. When is this value negative?.

Question (3)

For the following velocity distribution.

$$u/U_\infty = a + b\eta + c\eta^2 + d\eta^3$$

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

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

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

iii. Calculate the displacement thickness (δ^*) and momentum thickness (θ) in terms of δ.

Question (4)

4.a Consider the steady-state two-dimensional heat conduction. Show that the steady-state temperature distribution on a heated plate can be modeled using the equation

$$\frac{\partial^2 T}{\partial x^2} + \frac{\partial^2 T}{\partial y^2} = 0$$

For the square grid ($\Delta x = \Delta y$) and using the approximation of $\partial^2 T/\partial x^2$ and $\partial^2 T/\partial y^2$, show that the above equation can be written as

$$T_{i+1,j} + T_{i-1,j} + T_{i,j+1} + T_{i,j-1} - 4T_{i,j} = 0$$

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

Question (5)

Consider the problem of heat conduction with uniform heat generation (q) in a rod whose ends are maintained at constant temperatures of T_0 = 100°C and T_5 = 200°C respectively. The one-dimensional problem is governed

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

Take rod length L equals 2 cm, thermal conductivity k equals 0.5 W/m.K, heat generation q equals 10^6 W/m^3, cross-sectional area A is 1 m^2, $\delta x = 0.5$ cm.

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, T_4 at x = 2.5, 7.5, 12.5, 17.5 mm respectively.

ii. Using the control volume method, obtain the discretised equation for nodal points 2 and 3, the discretised equation for nodal point 1, and the discretised equation for nodal point 4.

Good Luck

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