Menoufia University
Faculty of Engineering
Shebin El-Kom
1th Semester
Academic Year: 2016-2017

Post Graduate: Master
Department: ***Mechanical Power Engineering***
Subject: Computational Fluid dynamics
(MPE620)
Time Allowed: 3 hrs
Date: 8/1/2017

Note: Assume any data required , state your assumption clearly. Answer all the following Questions

Question (1) (30 Marks)

A property ϕ is transported by means of convection and diffusion through the one – dimensional domain sketched in Fig. 1. The governing equation is $\frac{d\rho u\phi}{dx}=\frac{d}{dx}\left(\Gamma(\frac{d\phi}{dx})\right)$ the boundary conditions are $\phi_o=1.0$ at x=0 and $\phi_L=0.0$ at x=L. Using five equally spaced cells and the upwind differencing scheme, calculate the distribution of ϕ as a function of x. The following data apply u=0.1 m/s, length L=1.0 m, ρ=1.0 kg/m^3, $\Gamma=0.1$ kg/m.s.

Question (2) (30 Marks)

In Fig. 2 a two- dimensional plate of thickness 1cm is shown. The governing equation is $\frac{\partial}{\partial x}\left(k(\frac{\partial T}{\partial x})\right)+\frac{\partial}{\partial y}\left(k(\frac{\partial T}{\partial y})\right)=0.0$. The thermal conductively of a plate material is k=1000 W/m.K. The west boundary receives a steady heat flux of 500 kW/m^2 and the south and east boundaries are insulated. If the north boundary is maintained at a temperature of 100 °C, use a uniform grid with $\Delta x=\Delta y=0.1$ m to calculate the steady state temperature distribution at nodes

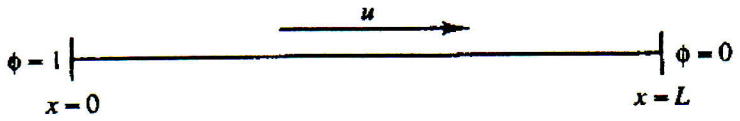

Fig. 1

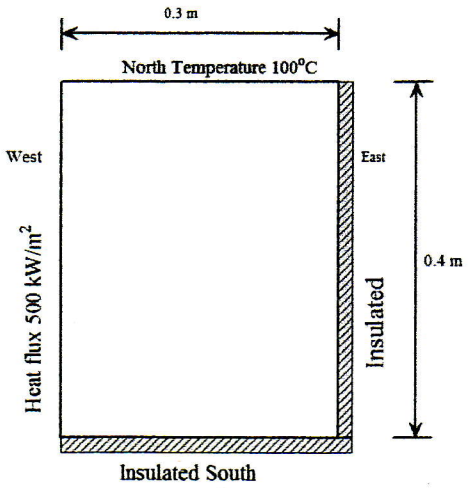

Fig. 2

Question (3) (40 Marks)

The *x*- component of Navier-Stokes equation for two-dimensional porous media with no body force can be written as: $\frac{\partial\rho u^2}{\partial x}+\frac{\partial\rho uv}{\partial y}=-\frac{\partial p}{\partial x}+\frac{\partial}{\partial x}\left(\mu\frac{\partial u}{\partial x}\right)+\frac{\partial}{\partial y}\left(\mu\frac{\partial u}{\partial y}\right)-k(u^2+v^2)$

Where last term represent additional resistance due to porous media

a) Drive the finite volume difference equation over a staggered grid and show how the under-relaxation affects the coefficient of the obtained equation.
b) Drive an expression for pressure correction equation using SIMPLE algorithm.
c) How the source term be linearized?
d) Draw a flow chart for the solution of 2-D fluid flow in straight duct.

GOOD LUCK

Dr. Samy M. El-Behery & Dr. Ismail M. Sakr