Menoufiya University
Faculty of Engineering
Shebin El-Kom
First Semester Examination
Academic Year: 2014-2015

Minufiya University

Year: Post Grad. (PhD. Prep.)
Department: Mechanical Power
Subject: *Fluid Mechanics* MPE711
Time Allowed: 3 hours
Date: 10.01.2015

Allowed Tables and Charts: None

Answer all the Following Questions *(100 Marks for all)*

Question (1) *(50 Marks)*

A. For 3-dimensinal incompressible flow develop the continuity and Navier-Stokes equations in Cartesian coordinates. Reduce the final forms to steady incompressible flow. ***(20 Marks)***

B. Explain how to develop the turbulent Reynolds-stresses tensor matrix in three-dimensional turbulent flow. ***(15 Marks)***

C. To close the system of Reynolds-averaged Navier-Stokes equations (RANS) given in question (1-B), we must find enough equations to solve for our unknowns. Describe how to develop a simple linear turbulence model for solving the RANS equations (k-ε turbulence model). Define all terms in the developed equations. ***(15 Marks)***

Question (2) *(50 Marks)*

A. Give a brief outline of the Blasius solution of laminar boundary layer for flow over a flat plate in the form: $ff'' + 2f''' = 0$. What are the boundary conditions from which the analytical solution can be developed. Write the function of the boundary layer and displacement thicknesses developing in streamwise direction. ***(20 Marks)***

B. The velocity profile in a laminar boundary layer over a smooth flat plate (length L) immersed parallel to the flow stream can be approximated by a fourth degree polynomial velocity distribution as follows:

$$\frac{u}{U_\infty} = a + b(\frac{y}{\delta}) + c(\frac{y}{\delta})^2 + d(\frac{y}{\delta})^3 + e(\frac{y}{\delta})^4$$

(I) Compute the coefficients a, b, c, d and e. ***(10 Marks)***

(II) Prove the validity of the following relations: $\delta_1/\delta = 3/10$, $\theta/\delta = 37/315$, $\delta/x = 5.48/\sqrt{\mathrm{Re}_x}$ and $C_d = 1.37/\sqrt{\mathrm{Re}_L}$, where C_d is the drag coefficient. ***(10 Marks)***

C. Discuss the different regions in the boundary layer. Write the law of the wall, from which how do you derive the Clauser's plot relation? ***(10 Marks)***

Best wishes

Professor Wageeh El-Askary