Menoufiya University
Faculty of Engineering
Shebin El-Kom
First Semester Examination
Academic Year: 2013-2014

Year: Post Grad. (PhD. Prep.)
Department: Mechanical Power
Subject: Advanced Fluid Mechanics
Time Allowed: 3 hours
Date: 21.01.2014

Allowed Tables and Charts: None

Answer all the Following Questions

Question (1) ***(50 Marks)***

A. Derive the Navier-Stokes equation for unsteady three-dimensional incompressible flow. Reduce the final forms to steady incompressible flow. ***(20 Marks)***

B. An incompressible fluid flow between two fixed parallel-horizontal plates is allowed under a constant pressure gradient (dp/dx=constant). Give the suitable assumptions to reduce the derived Navier-Stokes equations and derive the velocity distribution, the maximum velocity, the average velocity, the local wall shear stress and the flow rate between the plates. ***(20 Marks)***

C. Explain how to develop the Reynolds-stresses matrix. ***(10 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. ***(15 Marks)***

B. Derive the growth of the turbulent boundary layer thickness, the displacement thickness, the momentum thickness and the wall skin friction coefficient of a turbulent flow over a flat plate. How do you compute the total drag force of the plate? ***(15 Marks)***

C. 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:

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

(I) Compute the coefficients a, b, c, d and e. ***(5 Marks)***

(II) Prove the validity of the following relations: $\delta_1/\delta = 3/10$, $\theta/\delta = 37/315$, $\delta/x = 5.84/\sqrt{\mathrm{Re}_x}$ and $C_d = 1.37/\sqrt{\mathrm{Re}_L}$, where C_d is the drag coefficient. ***(5 Marks)***

D. 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
Assoc. Professor Wageeh El-Askary