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

Year: Post Grad. (PhD. Prep.)
Department: Mechanical Power
Subject: *Fluid Mechanics* MPE711
Time Allowed: 3 hours
Date: 08.06.2014

Allowed Tables and Charts: None

Answer all the Following Questions

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. ***(20 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:

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

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

Question (2) ***(50 Marks)***

A. Explain with neat sketches the following terms:
Length scale, Energy cascade, Energy backscatter, Two-point correlation. ***(8 Marks)***

B. For a boundary layer flow, derive the momentum integral equation of von –Kármán, in which the momentum thickness Θ and displacement thickness δ_1 are related to the wall shear stress τ_w with the presence of pressure gradient and free-stream velocity U_∞ as the following relation: $\frac{d\theta}{dx} + \frac{1}{U_\infty}\frac{dU_\infty}{dx}(2\theta + \delta_1) = \frac{\tau_w}{\rho U_\infty^2}$ ***(18 Marks)***

C. 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 (without pressure gradient). How do you compute the total drag force of the plate? ***(14 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