MAE 214A, Spring 2017

Homework 2

Due Thursday, May 4, in class

Guidelines: Please turn in a *neat* homework that gives all the formulae that you have used as well as details that are required for the grader to understand your solution. Note that the work must be your own; no use of solutions from other sources.

1. Consider a self-similar, turbulent round wake.

(a) Start from the axisymmetric boundary layer equations to obtain the powerlaw dependence of the wake half-width, $R(x)$, and the wake centerline deficit, $U_s(x)$ on the streamwise distance, x.

(b) Continue to solve Prob. 5.39, Pope.

(c) Write the TKE equation, explaining the physical significance of each term. Discuss the TKE balance in a round wake using Pope's book as a reference.

2. Consider the wake of a sphere.

(a) As $Re = UD/\nu$ increases, there is a so-called drag crisis at a critical value of Re. What is the drag crisis and at what value of Re does it occur?

(b) The time-dependent quantities (velocity, drag) in the subcritical regime exhibit discrete spectral peaks. Discuss the spectral peaks and their origin based on Yun et al. [2006] and Rodriguez et al. [2011].

(c) Visualizations of the velocity field show a helical mode. What is the helical mode, based on your reading of Yun et al. [2006] and Rodriguez et al. [2011]? Can the mean (obtained by time averaging) velocity be axisymmetric in spite of a helical mode?

References

I. Rodriguez, R. Borell, O. Lehmkuhl, C. D. Perez Segarra, and A. Oliva. Direct numerical simulation of the flow over a sphere at Re = 3700. *J. Fluid Mech.*, 679:263–287, 2011.

G. Yun, D. Kim, and H. Choi. Vortical structures behind a sphere at subcritical Reynolds numbers. *Phys. Fluids*, 18(1):5102, 2006.