ME 544 Homework 3 April 2018

Fluid Turbulence

For Thursday, 5 April

Read chapter 10 of the text.

For Thursday, 12 April

1. Do problem 10.8, page 378 of the text.

2. In the paper by Comte-Bellot and Corrsin (*J. Fluid Mech.*, **49**(2): 273-337, 1971), which has been put on the course website as a handout, two separate grid experiments are reported, one for a grid mesh size M of 5.08 cm, and the other for a grid mesh size of 2.54 cm. For each experiment, at several downstream distances measured as $\frac{x}{M} = \frac{U_0 t}{M}$, in particular the root-mean-square velocity $\sqrt{\overline{u_1^2}}$ and the average kinetic energy dissipation rate ϵ are given in dimensional units in Table 4, page 299.

Consider the k-ϵ model for this case. Note that the flow fields are approximately homogeneous and isotropic, and without any mean shear; therefore the k-ϵ modeling equations simplify greatly as discussed in class.

1. Initialize the values of k and ϵ at the first values given for each experiment, i.e., at $\frac{U_0 t}{M} = 42$ ($M = 5.08$ cm) and at $\frac{U_0 t}{M} = 45$ ($M = 2.54$ cm). Using either analytical solutions or numerical methods to solve the k-ϵ equations in time t (or in x) for each case, find the value of the coefficient $C_{\epsilon 2}$ which approximately optimizes the agreement between the model prediction and the data.

2. Plot $k(t)$ and $\epsilon(t)$ for each experimental case [both cases can be put on 2 plots, one for $k(t)$ for both cases and one for $\epsilon(t)$ for both cases]. For both $k(t)$ and $\epsilon(t)$, plot one curve using the optimized value of $C_{\epsilon 2}$ which you obtained, and a second curve using the recommended value, 1.92. Put the laboratory data points on the appropriate plots.

3. Comment on the agreement between the model results and the experimental results. Why would the recommended value, 1.92, differ somewhat from the value obtained from the best fit for the data?