I. P. Castro & C. Vanderwel, *Turbulent Flows: An Introduction*, IOP, 2021.

Chapter 5 Sample Exercises

5.1 The file "HITData.txt" tracks the variation with time of properties of decaying isotropic turbulence, from a 512^3 DNS by Wray (1997). The data include total energy, enstrophy and integral length scale.

a. Plot the total kinetic energy energy vs. time and determine the exponent of the best power law fit (equation (5.3)).

b. Determine the rate of turbulent kinetic energy dissipation using (i) $\epsilon = -\mathrm{d}k/\mathrm{d}t$ (equation (5.1)) and (ii) $\nu\overline{\omega_i'\omega_i'}$ (equation (2.31)).

c. Plot the development of the integral length scale in time.

d. Explore the validity of the equilibrium dissipation law (equation (5.26)) and estimate C_ϵ.

5.2 The file "HSFData.txt" contains measurements of the growth of the turbulent kinetic energy and Reynolds stresses in a wind tunnel realisation by Tavoularis and Karnik (1989) of a homogeneous shear flow with $\beta = 84$ s^{-1}.

a. Calculate the turbulent kinetic energy and plot it to see how it varies downstream. Does it grow or decay?

b. Fit a line to the plot of k vs τ using a logarithmic y-axis to determine the exponent of the exponential function $k = k_o e^{a\beta t}$ (equation (5.39)), noting that in this case $\tau \approx \beta t$. Compare this value of a with that predicted by $a = \frac{\epsilon}{\beta k}\left(\frac{P_k}{\epsilon} - 1\right)$, noting that $P_k = -\beta\overline{u'v'}$ and $\epsilon = P_k - \beta\frac{\mathrm{d}k}{\mathrm{d}\tau}$.

c. Determine the anisotropy coefficients defined by equation (5.38).