Exercise 5: Some simple turbulent flows

Isotropic decaying turbulence

Problem 1:

a)
Use the k-ε model and determine k and ε as functions of time for isotropic turbulence without supply of energy.

b)
Experimental results shows that k decays as $k \sim t^{-1,25}$. Use this to determine a value forf $C_{\varepsilon 2}$ in the k-ε-model.

c)
Which physical limits are there for the value of $C_{\varepsilon 2}$?

d)
Assume that the turbulence energy of isotropic turbulence decays a $k \sim t^{-n}$. Determine how the ("Taylor") length scale λ_g develops with time.

λ_g can be expressed from Eq. (7.39) in the textbook.

Boundary layers

Problem 2:

In a turbulent flow along a wall, a boundary layer is formed.
Is is found that in a region near the wall, the shear stress is approximately equal to the shear stress at the wall τ_{w}. In a part of this region, the velocity can be calculated from Prandtl's mixing length model by setting the mixing length , $\ell = \kappa y$. Here, $\kappa = 0{,}4$ is the von Karman constant and y is the distance from the wall.

a)
Determine the profile for mean velocity in this region.

b)
How will the velocity profile be quite near the wall?

c)
In the region near the wall, production and dissipation is approximately equal in the k equation, and the convection of ε can be neglected. Use this information to express a relation between C_μ, $C_{\varepsilon 1}$, $C_{\varepsilon 2}$, and σ_ε in the k-ε model.