**Zusammenfassung der Lektüre „Turbulent Flows“ von Stephen B. Pope**

Chapter 1:

* turbulent motion occurs in many scales
* in this case the flow is unsteady, unpredictable and irregular
* velocity field varies irregularly in both space and time
* turbulent flows take place in almost every engineering related topic, i.e. in airplanes, car aerodynamics, mixers etc.
* turbulent flows are able to mix (matter, heat) and transport fluids much faster than laminar flows
* at high Reynolds numbers a “separation of scales” takes place, where the large-scaled flows are mostly influenced by the geometry of the flow (boundary conditions), small-scaled ones are influenced by the viscosity of the fluid and the rate they receive energy from the large-scaled flows
* Navier-Stokes-Equations describe the turbulent flows accurately and in detail, but they can’t separate between the scales and show every detail of the flow -> they don’t represent a tractable model
* direct simulation with use of the navier-stokes-equations is calles direct numerical simulation (DNS), this method works just for moderate Reynolds numbers

Chapter 3:

* in a turbulent field, the velocity U(x,t) is random
* random means neither certain nor impossible
* the random character of turbulent flows is made due to two facts:

1. there are unavoidably pertubations in the experimental conditions
2. turbulent flows are very sensitive to this changes

* these perturbations can’t be eliminated, they can only be reduced
* the goal of simulating the flow is to achieve information on the probabilities of an event, not on the particular value
* find the ‘Propability Density Function’ (PDF) of the flow
* the ‘Cumulative Distribution Function’ describes the likelihood of a certain case (f.e. U<Va), it is defined as
* this function has three basic properties:

1. for Vb>Va -> CDF is a non-decreasing function

* The PDF is the derivative of the CDF
* , , ,
* PDF and CDF fully characterize a random variable, if two or more random variables show the same PDF or CDF, they are called ‘equally distributed’ or ‘statistically identical’
* examples of propability distributions:

1. The uniform distribution
2. The exponential distribution
3. The normal distribution (Gaussian distribution)
4. log-normal distribution

* Cauchy-Schwartz-inequality:
* if the variables are fully correlated, if they are fully negatively correlated, if they are not correlated at all
* one-time CDF and PDF only contain information of a specific point in time, they can’t tell us about two or more different times -> finding joint PDFs for every point in time is an impossible task
* a turbulent flow can reach a statistically stationary state after an initial transient period (a state, in which all mean flows are invariant to time)
* isotropic turbulence: flow field is statistically invariant to rotations, reflections and shifts in the origin of the coordinate system
* definition of mean flow:

Chapter 6:

* turbulent motions range in size from the width of the flow to much smaller scales
* this scales become smaller with rising Reynolds numbers
* energy cascade: The energy enters the turbulence at the largest scales, and is passed through and through to the smallest ones where the energy dissipates in viscous action

Energy cascade:

* turbulence is made of eddies of different sizes (eddy: turbulent motion inside a locked-up region of size l, which is at least moderately coherent over this region; an eddy can include other smaller eddies)
* the biggest eddies break up in smaller ones and so on, until the Reynolds number is small enough that the energy can dissipate viscous

Kolmogorov hypotheses:

* both velocity and timescales decrease when decreasing the size of the eddies
* large eddies are highly affected by the boundary conditions of the flow

1. Hypotheses: At sufficiently high Reynolds number, the small-scale turbulent motions (l<<l0) are statistically isotropic.
2. Hypotheses: In every turbulent flow at sufficiently high Reynolds number, the statistics of the motions of scale l in the range l0>>l>> have a universal form that is uniquely determined by (dissipation rate), independent of (viscosity).