TECHNICAL FLUID MECHANICS
Ae 204

COURSE OUTLINE

Garry Brown and Anatol Roshko

This course discusses both free and wall-bound turbulent shear flows based on the results of key experiments and new insights available from DNS calculations in which quantities that could not be measured in experiment are now available. It presents a vorticity-based point of view.

Some important themes that recur frequently include:

- Vorticity and vorticity transport
- Flow structure
- Instability
- Asymptotic behavior
- Equilibrium (or similarity) flows
- Non-equilibrium flows

In free turbulent shear flows asymptotic ideas are compared with the results from measurements. Peak Reynolds stress, the transport of vorticity, entrainment and mixing are found to be strong functions of the underlying geometry of the flow. Numerical simulation helps in an understanding of the mechanics.

A discussion of channel flow, Couette flow and pipe flow, for which the mean flow is independent of the stream-wise location, follows. Asymptotic behavior of wall-bound flows leads to the Law of the Wall, and the Log law. Vorticity transport, available from simulations, provides a particular view of the fundamental source of Reynolds stress.

More complex turbulent shear flows are discussed where a state of equilibrium has not been or cannot be established, or if it existed initially has been disturbed. Many geophysical turbulent flows are essentially incompressible but have non-uniform density. For such flows, the Boussinesq approximation adds the baroclinic torque to the vorticity equation. Plumes subject to off-source heating, as in cumulus cloud formation, offer a case of an equilibrium turbulent flow suddenly disturbed. The re-laminarizing turbulent boundary layer is an interesting and important example of a more complex turbulent shear flow in which equilibrium is rapidly disturbed and for which a mechanistic understanding is sought. The intention is to show the wide variation in the behavior of turbulent flows and to understand their basis in flow structure and vorticity transport.

Turbulence energy and its dissipation, the scales of motion and the spectrum of the fluctuations are considered. A ‘vortex force’ point of view presents another perspective.

The aim is a systematic and coherent presentation of material that is relevant to the main objective which is to gain insights into the mechanics of turbulent shear flow through experimental, conceptual and computational developments in the subject.