

BENGAL ENGINEERING & SCIENCE UNIVERSITY, SHIBPUR
M.E., 1st Semester November/December 2013
FLUID TURBULENCE – I (AM 910)

Full Marks 70

Time – 3 hours

Answer any five questions

Each question carry equal marks

1. Derive the Poisson's equation. What are the characteristics of turbulent flow. Describe the experiments of Taylor and Benard in the context of transition to turbulence .
2. Explain the concept of an eddy in the context of vorticity dynamics. Derive the Bernoulli's form of the Navier Stokes equation and hence derive the vorticity equation.
3. What is vortex stretching? Explain mathematically how vorticity can be intensified by stretching of fluid elements. What is the strain rate tensor? How it is related to shear stress? What is enstrophy?
4. Derive the Reynolds equation of motion for the averaged velocities. Explain why the extra terms that appear out of the process of averaging are called Reynolds stress. Discuss the advantages and disadvantages of time averaging the Navier Stokes equation.
5. Show that the energy equation for fluid flow can be written in the form
$$\frac{\partial}{\partial t} \left(\frac{u^2}{2} \right) = -\nabla \cdot \left[\left(\frac{u^2}{2} + p/\rho \right) \mathbf{u} + \nu (\nabla \times \mathbf{u}) \times \mathbf{u} \right] - \nu (\nabla \times \mathbf{u})^2.$$
The different notations carry their usual meaning. Hence explain the physical significance of the different terms of the above equation.
6. How do you understand by non-linearity? Explain the role of the non linear term in the Navier Stokes equation in the context of transition to turbulence. What is eddy viscosity? Compare eddy viscosity and dynamic viscosity of fluid in the generation of stress. Discuss the statement *vorticity cannot penetrate the walls of a vortex tube*. What are the Kolgomorov's micro-scales of turbulence?
7. What do you mean by intrusive and non-intrusive method of fluid flow measurement and site the measurement principle of two instruments in each category? What do you mean by instrument calibration? How is the distinction between a smooth bed flow and rough bed flow made? Explain the working principle of Laser Doppler Velocimeter.
8. What do you mean by kinetic energy of turbulence and turbulent dissipation? Explain how momentum transport occurs in a turbulent flow. Explain the working principle of a Hot Wire Anemometer.