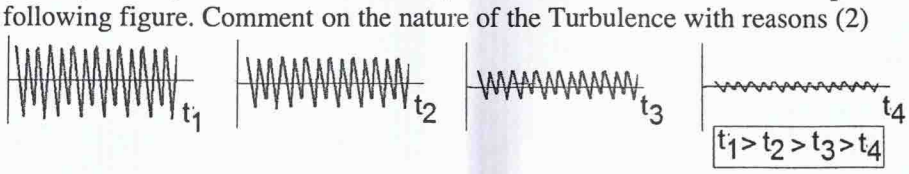
INDIAN INSTITUTE OF TECHNOLOGY KHARAGPUR
End-Autumn Semester 2017-18

Date of Examination: _____ Session (FN/AN) ____ Duration _3 hrs_ Full Marks:50
Subject No. : _CH61011_____ Subject: Advanced Fluid Dynamics_____
Department/Center/School : _____ Chemical Engineering_____
Specific charts, graph paper, log book etc., required Nil _____
Special Instructions (if any) : Make rational assumptions wherever necessary, No doubts will be clarified during the examination.

Part A

1. (a) What is Reynolds Decomposition of Turbulence? (1)
   b) Show that the continuity equation is satisfied by both mean as well as fluctuating components of velocity in turbulent flow. (2)
   c) What is Eddy diffusivity? What is its physical significance? (2)
   d) What is Prandalt Mixing Length? Correlate it to Eddy Diffusivity. (2)
   e) At a specific point in the flow field, the time resolved fluctuation spectrum is given in the following figure. Comment on the nature of the Turbulence with reasons (2)



   (f) Write down some limitations of the classical description of a Turbulent Boundary Layer in wall coordinate system. (1)

[Total Marks in Question 1: 10]

2. (a) Obtain the 2-D SS Boundary layer equations for a Laminar Flow of a Newtonian Fluid flowing over a flat plate, based on scaling analysis. What are the major assumptions in this formulation? (4+1)
   b) For what range of Reynolds number is the above analysis valid? (1)
   c) Why is the momentum boundary layer self similar? Discuss how can you define the expression of stream function $\Psi = \sqrt{\gamma x U_\infty}\, f(\eta)$, where η is the similarity parameter in Blasius Solution. (1+2)
   d) What is the physical significance of Reynolds Number within a boundary layer in an External flow? (1)
   e) What is shape of the boundary layer at the leading edge of a plate, upon which a flow with uniform profile is impinging? (1)
   f) Justify if the Boundary of the boundary layer is a stream line or not! (1)
   g) What is Boundary Layer Momentum Thickness? Find out Boundary layer momentum thickness assuming a polynomial Velocity profile. Mention the boundary conditions clearly (1+2)

[Total Marks in Question 2: 15]

Part B

1. A viscoelastic material undergoes under simple shear between two parallel plates. Take 1 as the flow direction, 2 as the direction perpendicular to plate surface and 3 as the remaining direction in a Cartesian division. Answer the following: