INDIAN INSTITUTE OF TECHNOLOGY KHARAGPUR

End-Autumn Semester Examination, 2015-2016

Subject: **Advanced Fluid Dynamics** *Subject No.*: **CH 61011**

Time: 3 Hrs *Full Marks*: 50 No. of Students: 107

Instructions:

1. All Questions are compulsory.
2. Clearly write your Name, Roll No., Subject Name, and Subject Number on the Answer Book.
3. Fell free to assume any missing data with proper justifications.
4. Please answer all the questions of each part together. **Also, all sub parts of each question MUST be together.**
5. Be Precise with your answers. Long, redundant answers can potentially fetch zero!

PART A

1. Explain **in not more than one paragraph**, why is a tensorial notation over a vectorial notation becomes essential for properly describing the applied stress-deformation behaviour of a non-Newtonian fluid? (5 marks)
2. A step increase in strain is given to a material. Describe the relaxation behavior if the material is (a) elastic solid; (b) Newtonian; (c) non-Newtonian. Show the response graphically (3x2=6 marks).
3. **In not more than one paragraph**, describe what is Deborah number and its significance in non-linear rheology (4 marks)
4. What is dynamic boundary condition? Why is it introduced for expressing hydrodynamics at a surface?. Explain with the help of a figure (5 marks)
5. In a shearing flow of a particulate suspension, what is the significance of Bernoulli's and Brownian stresses, considering the flow of particle within the liquid (5 marks).

PART B

6. a) Obtain the 2-D SS Boundary layer equation for a Laminar Flow of a Newtonian Fluid flowing over a flat plate, based on scaling analysis.
   b) For what range of Reynolds number is the above analysis valid?
   c) Solve the boundary layer equation by Blasius method. (you are required to show the final ODE. Show clearly how the similarity parameter is obtained, and also show step by step how the ODE can be obtained. Write the appropriate boundary conditions. Discuss how this ODE can be solved.
   d) What is the physical significance of Reynolds Number within a boundary layer in an External flow?
   e) What is shape of the boundary layer at the leading edge of a plate, upon which a flow with uniform profile is impinging? (3+1+(5+2)+1+1)=13

7. a) What is Reynolds Decomposition of Turbulence? Obtain an expression for the turbulent shear stresses for a 3-D SS flow field.
   b) Show that the continuity equation is satisfied by both mean as well as fluctuating components of velocity in turbulent flow.
   c) What is Eddy diffusivity? What is its physical significance?
   d) What is Prandalt Mixing Length?
   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. ((1+4)+3+2+1+1=12)