INDIAN INSTITUTE OF TECHNOLOGY KHARAGPUR

Mid-Autumn Semester Examination, 2015-2016

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

***Time*: 2Hrs** **No. of Students: 106** ***Full Marks*: 30**

***Instructions*:**

1. All Questions are compulsory.
2. Clearly write your Name, Roll No., Subject Name, and Subject Number on the Answer Book.
3. **. Also, all sub parts of each question MUST be together.**
4. Be Precise with your answers. Long, redundant answers can potentially fetch zero!
5. **No doubts will be clarified in the examination hall.**

PART A

1. Clearly explain how 'dynamic boundary conditions' are derived for flow on a 2D surface from Navier Stokes equation. Mention clearly both normal and tangential resolution of forces (4+4= 8 marks)

2. Two forces of equal magnitude are acting in opposite directions at both ends of a cylindrical rod of cross-sectional area A. The rod is held in a vertical fashion (the net downward force is inclusive of gravitational force).

   Address the following questions with a neat diagram.

   (a) Explain how will you find the state of stress at any point P, which lies somewhere in the middle of the cylinder (4 marks)

   (b) What are the normal and shear stresses acting on a plane that cuts across the rod at point P. (3 marks)

PART B

All parts of question No. 3 must be written sequentially at one place

3. (a) Derive expression of Angular Deformation and rotation of a fluid element at a constant Z plane. (1.5+1.5=**3**)

   (b) Explain the different components of τ_{ij}. Highlight their general dependence. (2)

   (c) What is a Stokesian Fluid? (1)

   (d) What is slip length? (Answer should contain a figure) (1)

   (e) If a drop of an evaporating liquid (low vapor pressure) is kept on a horizontal Surface, what will happen? Will there be any change in the scenario if there is some solute in the drop? (1+2=3)

   (g) What is the difference between advection and convection? Please explain it with the help of the equation of motion given below. (1)

$$\rho\left(\frac{\partial u}{\partial t}+u\frac{\partial u}{\partial x}+v\frac{\partial u}{\partial y}+w\frac{\partial u}{\partial z}\right)=-\frac{\partial p}{\partial x}+\left(\frac{\partial \tau_{xx}}{\partial x}+\frac{\partial \tau_{xy}}{\partial y}+\frac{\partial \tau_{xz}}{\partial z}\right)+\rho g_x$$

(Total:11 marks)

4. Derive an expression for shear stress for flow of a power law fluid between two infinitely wide parallel flat plates. Use the equation above, to formulate the equation of motion for Y an dZ directions. All assumptions must be clearly stated. The functional form of the continuity equation for Cartesian coordinate is deliberately not given. **(Total:4 marks)**