INDIAN INSTITUTE OF TECHNOLOGY KHARAGPUR
Mid-Autumn Semester Examination 2022-23

Date of Examination: **26.09.2022** Session: (FN/AN) **FN** Duration: **2 hrs** Full Marks: **30**

Subject No. : **CH61011** Subject : **Advanced Fluid Dynamics**

Department: **Chemical Engineering**

Specific charts, graph paper, log book etc., required: ONE graph paper per student

Special Instructions (if any): Make rational assumptions if necessary, No questions/doubts will be entertained during exam time

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PART A

1. The relationship between shear stress and shear rate for test fluids has to be obtained by using a simple design of a narrow capillary tube. There is provision for measuring the volumetric flow rate (Q) through this system. Assuming that the test is done by keeping the narrow tube horizontally, answer the following.

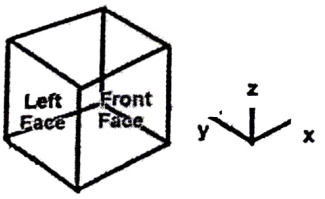
(a) Draw a clear diagram showing the direction of flow and the coordinate fixations. **(2 marks)**

(b) From fundamental fluid dynamics equations, derive an expression connecting shear stress and shear rate as in the case of (analogous to) Newton's equation of viscosity. Note that the final equation should contain only measurable parameters with respect to the narrow tube. If there are assumptions, clearly state them without which the derivation will be considered incomplete. **(10 marks)**

(c) If the fluid for which the shear stress-shear rate relationship has to be obtained is already known to possess some non-Newtonian characteristics (say either from its data sheet or some other secondary sources) is there any change in the above equation derived has to be made? If yes, what changes? **(3 marks)**

PART B

2. (a) Show that the value of stream function is constant along a stream line. (2)



(b) With the help of a suitable sketch please explain on which faces τ_{YZ} is active in a 3D flow field. (3)

(c) With the help of a 3D control volume derive the expression of Continuity equation for unsteady incompressible flow. (2)

(d) What is a fluid particle? (1)

(e) What is a Stokes Fluid? (1)

(f) Explain the different components of τ_{ij}. (2)

3. Find out the expression for shear stress profile in flow of a ***liquid*** of thickness "H" over an inclined plane making an angle θ to the horizontal. Use the Navier's Equations for the Cartesian System. State all the assumptions/ conditions that you have used. (4)
(Note: No Governing Equation will be supplied separately)