Bengal Engineering and Science University, Shibpur
B. E. (Aero.) Part-II 4th Semester Final Examination, 2012

Viscous Fluid Flow (AE 401)

Time: 3 Hrs. Full Marks: 70

All questions are of equal value
Answer any five from the following Questions

1. a) Derive the equation of the principle of the conservation of linear momentum for an incompressible laminar flow in the r-direction. State and apply all the assumptions required.

   b) Derive the equation of the principle of the conservation of mass in cylindrical coordinate system.

2. a) Reduce the conservation of linear momentum equation for an incompressible laminar flow so that it becomes applicable to a flow between two parallel plates. State and apply all the assumptions required.

   b) Derive the expression for velocity distribution for the above flow.

3. a) Derive the expression for velocity distribution in a slipper bearing arrangement.

   b) Show that the coefficient of friction does not depend on viscosity of the fluid in a slipper bearing arrangement.

4. Verify the following invariant for two dimensional stress components:

   a. $(\sigma_{xx} - \sigma_{yy})^2 + 4\sigma^2_{xy} = (\sigma_{xx} - \sigma_{yy})^2 + 4\sigma^2_{xy}$
   b. $\sigma_{xx} + \sigma_{yy} = \sigma_{x\,x} + \sigma_{y\,y}$

5. a) Derive the expression for third degree polynomial for velocity profile of a incompressible boundary layer flow with non zero pressure gradient.

   b) Show that the Pohlhausen Parameter (Λ) for the above flow is limited by $-6 \leq \Lambda$ to prevent boundary layer separation.

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6. a) Assuming a quadratic boundary layer velocity profile derive the expressions for displacement thickness, momentum thickness and coefficient of drag for boundary layer flow over a flat plate held parallel to the flow.

b) Consider a NACA 2412 airfoil of 1.5 m chord. The Reynolds number based on chord is 3.1×10^6. Determine the boundary layer thickness at the trailing edge and coefficient of drag. Take critical Reynolds number 5×10^5. Also determine critical length from the leading edge beyond which the boundary layer becomes turbulent. Take freestream velocity 50 m/s and $\rho_\infty = 1.23$ kg/m^3 and $\mu_\infty = 1.789 \times 10^{-5}$ kg/(m)(s)

7. a) Derive the ordinary differential equation of the two dimensional boundary layer flow if the velocity at the edge of the boundary layer is assumed to be proportional to a power of distance along the boundary layer.

b) Based on the von Karman Integral Relation, determine the local friction coefficient for a flow over a flat plate held parallel to the flow.

c) Derive the expression for velocity profile where separation is prevented by boundary layer suction.