Bengal Engineering and Science University, Shibpur
B. E. (Aero.) Part-II 4th Semester Final Examination, 2013

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

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) For incompressible Couette flow find out the limiting expression of pressure gradient above which back flow will be established.

3. In a slipper bearing arrangement show that bearing of a load is not possible if the surfaces holding flow in between are held parallel to each other.

   b) Find out the position under the carriage where linear flow is established.

4. If a new coordinate system (x', y') is obtained from original coordinate system (x, y) by a rotation through an angle of 45^0, verify the invariants of the rates of strain that is

   $$\epsilon_{x'x'} + \epsilon_{y'y'} = \epsilon_{xx} + \epsilon_{yy}$$
   $$\epsilon_{x'x'}\epsilon_{y'y'} - \gamma_{x'y'}^2/4 = \epsilon_{xx}\epsilon_{yy} - \gamma_{xy}^2/4$$

   For the flow $u = ay$, $v = 0$

5. Derive the expressions for transformation of stress components due to rotation of the axes about the origin in two dimensions.

6. a) Assuming a cubic 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 smooth flat plate of 1.5 m length. The Reynolds number based on length is 4×10^6. 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 frees-tream 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 due to Blasius for the two dimensional boundary layer flow without any pressure gradient.

b) Using the results in the table below for the above equation find out the expression for displacement thickness (δ^*).

$\eta = y\sqrt{(V_\infty/(\nu x))}$	f	$f' = u/V_\infty$	f''
0.0	0.0	0.0	0.33206
1.0	0.16557	0.32979	0.32301
2.0	0.65003	0.62977	0.26675
3.0	1.39682	0.84605	0.16136
4.0	2.30576	0.95552	0.06424
5.0	3.28329	0.99155	0.01591