

Bengal Engineering and Science University, Shibpur  
M. E. (Engg. Mech.) 1<sup>st</sup> Semester Examination, 2011

Advanced Mechanics of Fluids I  
(Am 906)

Time : 3 hours

Full Marks : 100

Answer any four of the following.  
The questions are of equal value.

1.
  - a) Derive continuity equation in cylindrical coordinate system.
  - b) Derive the linear momentum equation in r - direction for a compressible laminar flow in cylindrical coordinate system.
2.
  - a) Derive the expression for ordinary third order differential equation for a boundary layer flow along a flat plate without pressure gradient.
  - b) Using the results of the equation mentioned above given in the table Q. 2 (b) supplied determine the expressions of displacement thickness, momentum thickness and coefficient of drag for a boundary layer flow along a flat plate without pressure gradient.
3.
  - a) Derive the expression for fourth order velocity profile of a incompressible boundary layer flow.
  - b) Show that the Form Parameter ( $\Lambda$ ) is limited to the range of  $-12 \leq \Lambda \leq 12$
  - c) Find out the value of Form Parameter at the leading edge of the flat plate.
4.
  - a) Derive the expression for a fourth degree polynomial for the velocity profile for a boundary layer flow over a flat plate held parallel to the direction of the flow.
  - b) Calculate the displacement thickness and momentum thickness for the velocity profile mentioned above.
5. If a polynomial of the fifth degree is assumed for the velocity profile in the boundary layer, determine the five constants from the appropriate boundary conditions.

Table 9.2(b) The function  $f(\eta)$  for the boundary layer along a flat plate at zero incidence, after L. Howarth [9]

$\eta = y \sqrt{\frac{U_\infty}{\nu x}}$	$f$	$f' = \frac{u}{U_\infty}$	$f''$
0	0	0	0.33206
0.2	0.00664	0.00641	0.33199
0.4	0.02656	0.13277	0.33147
0.6	0.05974	0.19884	0.33008
0.8	0.10611	0.26471	0.32739
1.0	0.16557	0.31979	0.32301
1.2	0.23795	0.36378	0.31659
1.4	0.32298	0.45627	0.30787
1.6	0.42032	0.51676	0.29667
1.8	0.52952	0.57477	0.28293
2.0	0.65003	0.62977	0.26675
2.2	0.78120	0.68132	0.24835
2.4	0.92230	0.72899	0.22809
2.6	1.07252	0.77246	0.20646
2.8	1.23099	0.81152	0.18401
3.0	1.39682	0.84605	0.16136
3.2	1.56911	0.87609	0.13913
3.4	1.74696	0.90177	0.11788
3.6	1.92954	0.92333	0.09809
3.8	2.11605	0.94112	0.08013
4.0	2.30576	0.95552	0.06424
4.2	2.49806	0.96696	0.05052
4.4	2.69238	0.97587	0.03997
4.6	2.88826	0.98269	0.02948
4.8	3.08534	0.98779	0.02187
5.0	3.28329	0.99155	0.01591
5.2	3.48189	0.99425	0.01124
5.4	3.68094	0.99616	0.00793
5.6	3.88031	0.99748	0.00543
5.8	4.07990	0.99838	0.00365
6.0	4.27964	0.99898	0.00240
6.2	4.47948	0.99937	0.00155
6.4	4.67938	0.99961	0.00098
6.6	4.87931	0.99977	0.00061
6.8	5.07928	0.99987	0.00037
7.0	5.27926	0.99992	0.00022
7.2	5.47925	0.99996	0.00013
7.4	5.67924	0.99998	0.00007
7.6	5.87924	0.99999	0.00004
7.8	6.07923	1.00000	0.00002
8.0	6.27923	1.00000	0.00001
8.2	6.47923	1.00000	0.00001
8.4	6.67923	1.00000	0.00000
8.6	6.87923	1.00000	0.00000
8.8	7.07923	1.00000	0.00000