AEROSPACE ENGINEERING DEPARTMENT

INDIAN INSTIYUTE OF TECHNOLOGY, KHARAGPUR

End Spring Semester (2000-2001) Examination
Time: 3 Hrs.

20.04.2001 AN **112002** **Incompressible Aerodynamics**

2nd Year B. Tech. (H) & M. Tech. (Dual Degree) **No of Students: 19+7**

Answer any six questions. All questions carry equal marks.

Assumptions, if required, can be made with appropriate justifications.

Some important relations which may be required:

$$\int_0^{\pi} \frac{\cos n\theta_0}{\cos\theta_0 - \cos\theta}\, d\theta_0 = \pi \frac{\sin n\theta}{\sin\theta}, \qquad \int_0^{c} \frac{dx_0}{x - x_0} = \ln \frac{x}{c - x}$$

Complex potential in the circle plane (f):

$$F(f) = V_\infty e^{-i\alpha} + \frac{i\Gamma}{2\pi} \frac{1}{f - f_0} - \frac{V_\infty a^2 e^{i\alpha}}{(f - f_0)^2}$$

Notations have their usual meaning unless specified otherwise.

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1. Construct a quadratic camber line such that the zero lift angle of attack is -1.2^o. Hence, calculate the pitching moment coefficient about the leading edge and the location of the center of pressure at zero degree angle of attack.

2. The lift curve slope of the NACA 23012 airfoil is 0.1080/deg and the zero lift angle of attack is -1.3^o. Find the lift and induced drag coefficient at an incidence of 7^o for an untwisted wing of aspect ratio 8.0 and taper ratio of 0.8, the cross-section being NACA 23012. Use lifting line theory and assume two terms to describe the bound vorticity distribution.

3. Show that the potential flow past a three-dimensional configuration can be solved completely by a distribution of source, and/or, doublet singularities on the surface of the configuration and the associated wake.

4. Dividing the camber line in to a number of segments and placing point vortices at the quarter length of each segment to simulate the lifting effects can solve a lifting airfoil problem. Consider a symmetric airfoil at an incidence α and take three segments to discretize the camber line. Find the tangential velocity at any point on the airfoil and the lift and pitching moment coefficients.

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5. Construct a step by step detailed and completed algorithm to solve an airfoil problem using piecewise uniform doublet distribution on the surface of the airfoil. Obtain the necessary induced velocity relation to be used.

6. A 20% thick Zhukovsky airfoil set at zero incidence to a free stream of 20 m/s has a lift coefficient of 0.3. What will be the lift coefficient and the velocity at the nose at 5^o?

7. Explain the following:

   i. Conformal mapping and critical points of a mapping.
   ii. Inviscid flow of a viscous fluid.
   iii. Velocity based and Potential based panel methods.
   iv. Vortex induced drag and its variation with incidence and aspect ratio.
   v. Camber line of an airfoil and its' influence on the airfoil lift.