Reg. No.										

MANIPAL INSTITUTE OF TECHNOLOGY
MANIPAL
(A constituent unit of MAHE, Manipal)

VII SEMESTER B.TECH. (AERONAUTICAL ENGINEERING)

END SEMESTER EXAMINATIONS, NOV/DEC 2018

SUBJECT: UNSTEADY AERODYNAMICS [AAE 4004]

REVISED CREDIT SYSTEM
(01/12/2018)

Time: 3 Hours MAX. MARKS: 50

Instructions to Candidates:

- Answer **ALL** the questions.
- Missing data may be suitable assumed.

1A. The vorticity vector $\vec{\omega}$ is defined from the velocity vector, $\vec{q}$, as follows $\vec{\omega} = \nabla \times \vec{q}$. Show that the vorticity vector satisfies the equation of continuity. Using the figure 1 below which shows an arbitrary surface S bounded by curve C, irrotationality, show that **(05)**

$$\iint curl\,\vec{q}.\hat{n}\,dS = \oint \vec{q}.d\vec{r}$$

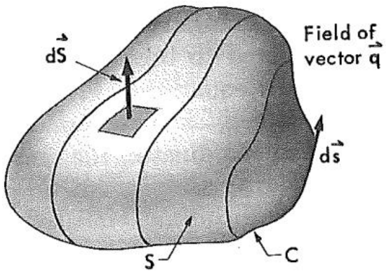

Figure 1

1B. Using in-body boundary conditions and by defining the airfoil by thickness and lifting components z_t and z_l respectively as shown in figure 2. Explain the concept of symmetry and antisymmetry. **(05)**

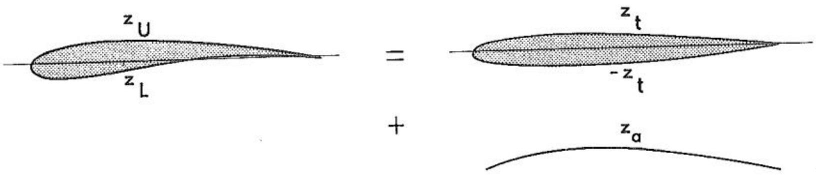

Figure 2

2A. Using the concept shown in the figure 3 below (neglecting the control surface deflection) for a 2-D airfoil in a supersonic unsteady flow with factor μ^2 given below, find the pressure difference using high and low frequency approximation. **(08)**

$$\mu^2 = (M^2 - 1)\left[\left(p + \frac{iM\omega}{a_\infty(M^2-1)}\right)^2 + \frac{\omega^2}{{a_\infty}^2(M^2-1)^2}\right]$$

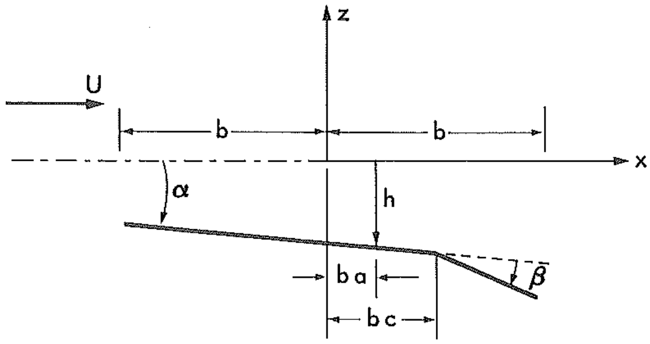

Figure 3

2B. For an isolated vortex and the associated velocity potential as shown in figure 4 below, write all the associated equations in polar coordinates. **(02)**

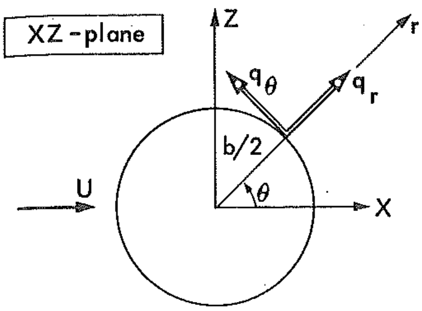

Figure 4

3A. Using the inference of figure 5 below, give the physical interpretation of Theoderson lift deficiency function $c(k)$ by comparing circulatory lifts in exact and quasi-steady equations produced by motion. What is quasi-static approximation? **(05)**

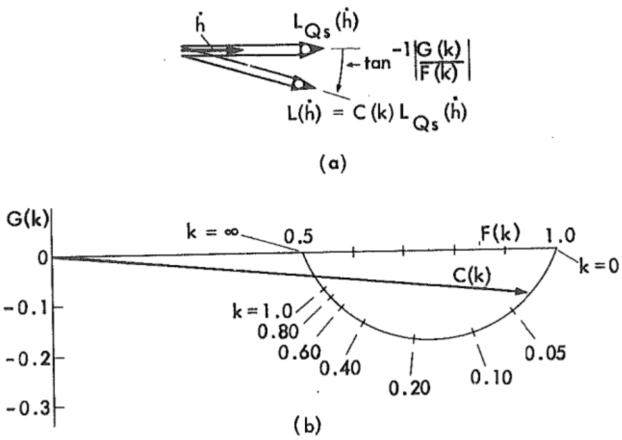

Figure 5

3B. Explain $V - g$ method as a graphical approach of flutter point calculation. **(05)**

4A. A wing bending–torsion system (in SI units) is modelled in terms of coordinates α and θ: **(08)**

$$12\ddot{\alpha} + 6V\dot{\alpha} + (4 \times 10^5 - 9V^2)\alpha + 3V\dot{\theta} + 3V^2\theta = 0$$

$$-3V^2\alpha + \ddot{\theta} + V\dot{\theta} + V^2\theta = 0$$

Determine the critical flutter speeds and corresponding frequencies using the Routh–Hurwitz approach.

4B. Euler equation numerical solver for a delta wing with 75^0 sweep at $M = 1.95$ and 10^0 angle of attack gives the normal force coefficient as $CN = 0.295$. Find the normal force coefficient with Polhamus theory. **(02)**

5A. Using the appropriate conditions and Gauss theorem, show that momentum equation with five unknowns and four equations (velocity $\vec{q}$) is given as: **(07)**

$$\left[\frac{\partial \vec{q}}{\partial t} + (\vec{q}.\nabla)\vec{q}\right] = -\frac{\nabla p}{\rho}$$

5B. During dynamic stall as shown in figure 6, the drag coefficient is less for pitch-up than for pitch-down, whereas the lift coefficient is larger for pitch-up than for pitch-down. Why? **(03)**

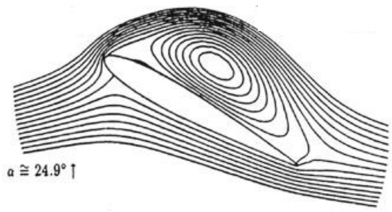

Figure 6

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