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
(02/01/2019)

Time: 3 Hours MAX. MARKS: 50

Instructions to Candidates:

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

1A. For an incompressible flow in two dimensions with incompressible condition $\nabla^2 \emptyset = 0$, show that: **(07)**

$$L = U_\infty \rho_\infty \Gamma$$

1B. With suitable assumptions and using first law of thermodynamics, show that for barotropic fluids **(03)**

$$\frac{P}{\rho^\gamma} = constant$$

2A. Using the radiation condition as shown in the figure 1 below, show that change in pressure for a thin airfoil in steady supersonic flow is given as: **(08)**

$$\Delta P = \frac{-\rho_\infty {U_\infty}^2}{\beta}\left[\frac{dz_L}{dx} + \frac{dz_U}{dx}\right]_{z=0^\pm}$$

Where $\beta = \frac{1}{\sqrt{M^2+1}}$. Use appropriate boundary conditions.

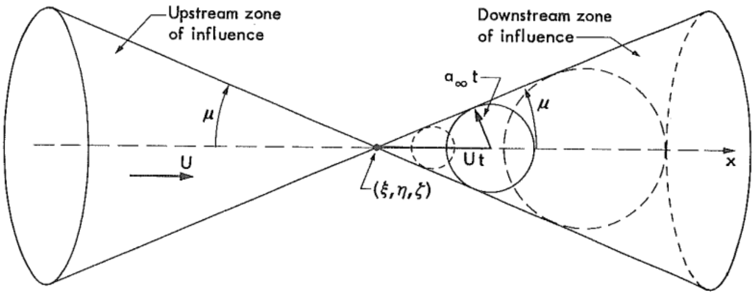

Figure 1

2B. Write the Söhngen's inversion formula used to furnish an integral expression for the unknown vortex strength $\bar{\gamma}_a$ in case of unsteady analysis. **(02)**

3A. Explain $p-k$ method as a graphical frequency matching approach of flutter point calculation. **(05)**

3B. State and prove Gauss theorem or divergence theorem, for a finite volume $\vec{V}$ with suitable diagrammatical representation. **(05)**

4A. A binary aeroelastic system (in SI units) takes the form **(08)**

$$\begin{bmatrix} 120 & 0 \\ 0 & 10 \end{bmatrix} \begin{bmatrix} \ddot{\theta} \\ \ddot{\gamma} \end{bmatrix} + \begin{bmatrix} 6V & 0 \\ -3V & V \end{bmatrix} \begin{bmatrix} \dot{\theta} \\ \dot{\gamma} \end{bmatrix} + \begin{bmatrix} k_1 & 4V^2 \\ 0 & k_2 - 3V^2 \end{bmatrix} \begin{bmatrix} \theta \\ \gamma \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \end{bmatrix}$$

where $k_1 = 5 \times 10^4$ Nm/rad and $k_2 = 7 \times 10^4$ Nm/rad. Determine the critical flutter speeds and corresponding frequencies using the Routh–Hurwitz approach.

4B. What are the seven fundamental equations of potential flow aerodynamic theory? **(02)**

5A. Figure 2 below shows a two DOF primitive dynamic aeroelastic model representing subsonic case. Derive the binary aeroelastic model in matrix format and explain flutter using the conditions with $q = 0$ and $q \neq 0$, **(08)**

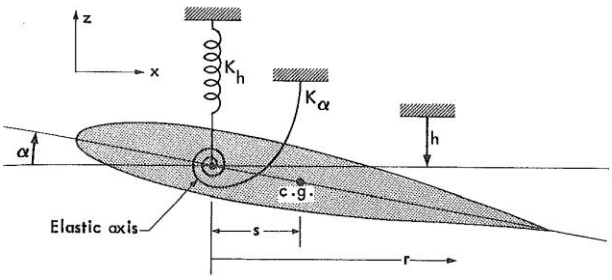

Figure 2

5B. The additional lift is called 'vortex lift' and it is predicted with the 'leading edge suction analogy' by Polhamus in 1970 using his theory. Explain vortex lift in brief. **(02)**