Reg. No.										

MANIPAL INSTITUTE OF TECHNOLOGY

MANIPAL

A Constituent Institution of Manipal University

VII SEMESTER B.TECH. (AERONAUTICAL ENGINEERING)

END SEMESTER EXAMINATIONS, DEC 2016/JAN 2017

SUBJECT: INTRODUCTION TO AEROELASTICITY [AAE 427]

REVISED CREDIT SYSTEM
(02/01/2017)

Time: 3 Hours MAX. MARKS: 50

Instructions to Candidates:

- Answer **ANY FIVE FULL** questions.
- Missing data may be suitable assumed.

1A. A side view of a two segment wing idealization is shown in Figure 1.1. These segments are connected by two springs, one with spring constant k *lb/inch* and the other with spring constant $2k$. Each wing segment has planform area *S.* Find the aero-elastic stiffness matrix and divergence dynamic pressure. (07)

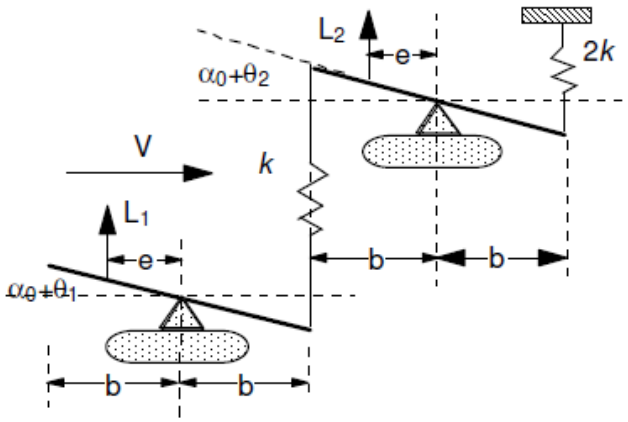

Figure 1.1

1B. What is P-k method of flutter formulation? (03)

2A. For an airfoil with a certain effective angle of attack and elastic twist, how do you measure the divergence dynamic pressure and divergence speed at reversal if the control surface has a deflection angle β. (07)

Justify: $$\frac{\Delta C_L}{\Delta C_L^r} = 1 - \left(\frac{U}{U_D}\right)^2 \left[\frac{1}{1-\left(\frac{U}{U_D}\right)^2}\right]\left[\frac{1-\left(\frac{U_R}{U_D}\right)^2}{\left(\frac{U_R}{U_D}\right)^2}\right]$$

2B. Derive beam equation using a small element of beam with distributed load $z(y)$. (03)

3A. Derive the Lagrange's equation from extended Hamilton principle for energy formulation for dynamical systems of rigid bodies. (07)

3B. What is principle of virtual work? Explain (03)

4A. Consider the more sophisticated and more realistic beam rod model of a large aspect ratio wing whose span is l and chord c and determine the divergence conditions to occur using equation (07)

$$\frac{d^2\alpha_e}{d\bar{y}} + \lambda^2\alpha_e = K$$

4B. What is Control Surface Reversal? Explain how the characteristics of a binary flutter system can be found through the use of Flutter Conic. (03)

5A. Suppose we have an aerofoil whose stiffness, chord etc. are not constants but vary with spanwise location and whose equilibrium equation is given as: (07)

$$\frac{d}{dy}\left(GJ\frac{d\alpha_e}{dy}\right) + qce\frac{\partial C_L}{\partial\alpha}\alpha_e = -qce\frac{\partial C_L}{\partial\alpha}\alpha_0 - qc^2C_{MAC_0}.$$

How will we estimate the divergence condition? Explain in detail

5B. How do you differentiate forced and geometric boundary conditions? (03)

6A. A wing bending–torsion system (in SI units) is modeled in terms of coordinates α and θ: (07)

$$12\ddot{\alpha} + 6V\dot{\alpha} + (4\times10^5 - 9V^2)\alpha + 3V\dot{\theta} + 3V^2\theta = 0$$
$$-3V^2\alpha + \ddot{\theta} + V\dot{\theta} + V^2\theta = 0$$

Find the critical flutter speeds between which the system is unstable, frequencies using Routh-Hurwitz Criterion.

6B. Draw the classical collar's diagram (or triangle) representing the aeroelastic phenomenon. (03)