Advanced Theory of Helicopter – Final Exam.

June 14th (Thursday) 11:00 – 13:00

1. Under the assumption of pure harmonic motion for pitch and heave motions, unsteady lift acting on a two-dimensional airfoil section is expressed as follows. Explain briefly each constituent in the expression, such as $k, C(k), L_Q, L_{NC}$. (10 Points)

$$L = C(k)L_Q + L_{NC}$$

2. Plot a typical Coleman diagram of the "Ground Resonance" for an articulated soft in-plane (soft lag) rotor. Explain briefly which points become instability regions, and which among the rotor blade or fuselage modes are involved in them. (10 Points)

3. On which basis, quasi-steady aerodynamics will be sufficient for the most analyses of the rotary wing aerodynamics? Why, will NOT the full-unsteady aerodynamics be required or useful in the rotary-wing aerodynamics, rather than it will be for the fixed-wing aerodynamics? (10 Points)

4. Between Theodorsen's lift deficiency function and Loewy's function, there exist a few differences. Please explain characteristics of each function and those differences. (10 Points)

5. Aeroelastic instabilities of rotary wings in hover indicate some kind of blade design constraints or helicopter operation limits. Describe briefly those limits related with two primary instability phenomena in hover. (Each 5 Points)
   1) Flap-lag flutter
   2) Pitch-flap flutter or pitch divergence

6. Describe briefly the difference between torsional divergence in fixed wing and pitch divergence in rotary wing, especially with respect to the offset between aerodynamic center and elastic axis. (10 Points)

7. In order to analyze the blade motion, there are basically two modeling methods: a rigid blade with a restrained spring and an elastic beam. However, in the first

category, the restrained spring used in both rigid flap and rigid lag blade representation has a different purpose from that used in a rigid torsion model. The restrained spring is used to represent a different object or properties. Describe the difference between the rigid flap-lag and rigid torsion model. (10 Points)

8. In the structural modeling of the rotating rotor blades, Coriolis' forces and its relevant contributions are considered in the moment equilibrium around the relevant hinges in the governing equation for a few cases. However, it is NOT ENTIRELY considered in the other few cases. What is the theoretical reason or basis used to decide whether it needs to be included or not, depending on the different situation of the modeling? (10 Points)

9. Descrbe briefly which components among the vibration frequencies the hub transmits from the rotating blades to the fuselage and why the rotor acts as a filter for such a few harmonics. (10 Points)

10. Describe briefly about the figure of merit (F.M.) (Provide a physical meaning instead of the detailed derivation of equations) and why it is not equal to 1.0 in practice. (10 Points)