Department of Aerospace Engineering

I.I.T. Kharagpur

Date of Examination : 25.09.2002

Spring Semester : 2002-2003

Subject Name : Introduction to Helicopter Engineering Course

Subject No. : 114011 No. of Students : 25, Year : 4th Year B.Tech.

Instructions : Answer ALL questions

1. State, with brief explanations, whether the following statements are true or false.
   a) concept of autogyro was first introduced by Paul Cornu.
   b) Autogyro can not take off vertically.
   c) Flapping angle is analogous to dihedral angle in fixed wing aircraft.
   d) Flapping hinge provides zero rolling moment.
   e) Number of blades in solid rotor configuration is four.
   f) Upward motion of helicopter is achieved by change of collective pitch.
   g) Compressibility effect on the advancing blade limits helicopter operation.
   h) In "all wood" blade, Balsa is used in forward portion of the blade.
   i) "All metal" blade will be used extensively in future.
   j) First advanced aerofoil for helicopter was developed by Piercy.

2. Draw diagrams only
   a) single rotor, side-by-side and tandem helicopter
   b) see-saw rotor
   c) fully articulated rotor indicating flapping hinge offset and lag hinge offset
   d) different planform shapes of rotor blades
   e) flow characteristics on sections of advancing and retreating blades
   f) angle of attack contour plots showing propagation of stalling with increasing forward speed

3. Show the following angles with sketches
    a) azimuth angle (ψ)
    b) coning angle (Γ)
    c) blade pitch (θ)
    d) inflow angle (ϕ)
    e) angle of the incidence (i)
4. Write short notes on
    a) Differences between autogyro and helicopter
    b) Civil and military use of helicopter
    c) Merits and demerits of helicopter and aircraft
5. Describe briefly
    a) limits of helicopter operation
    b) general design requirements of advanced aerofoils
    c) give numerical values of design parameters in tabular form for hover and forward flight.
6. Starting from Froude's momentum theory show that the induced velocity at the rotor disc is one-half of that at infinity downstream

    Also, show that, in hover, induced velocity at rotor disc is proportional to the square root of disc loading.
7. Starting from the fundamentals of Blade Element theory show that the thrust coefficient C_T for hover is given by

$$C_T = \frac{a.\sigma}{4}(\theta_t - \phi_t)$$

where rotations have their usual meanings.