Code No: 07A82104 **R07** **Set No. 2**

IV B.Tech II Semester Examinations,APRIL 2011
HELICOPTER ENGINEERING
Aeronautical Engineering

Time: 3 hours **Max Marks: 80**

Answer any FIVE Questions
All Questions carry equal marks

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1. (a) What do you understand by the term "NOTAR"? Describe one such system.
   (b) Explain with a sketch, the principle and functioning of 'Hinge-less rotor' Helicopter. [8+8]
2. (a) What are the principal details of an 'Hovercraft'. How does it obtain forward motion?
   (b) Describe the propulsion system of a hovercraft with sketches. [8+8]
3. (a) Describe thrust vectoring principle of an existing VTOL airplane.
   (b) Explain following terms with respect to helicopter:
      i. Lateral control.
      ii. Directional control. [8+8]
4. Discuss the relative merits of the compound helicopter design. In your discussion, consider propulsive and lift compounding as both separate and combined means of compounding. Why do you think a true compound helicopter has never been put into production? [16]
5. The downstream wake from the rotor hub can often affect the unsteady loads on the tail rotor and empennage, to the extent than adverse lateral airframe forces can be produced. Suggest at least two techniques that could be adopted to alleviate this problem. [16]
6. A rotor in a given flight condition has the following flapping motion with respect to the control axis (control plane): $\beta(\psi) = 6^0 - 4^0\cos\psi - 4^0\sin\psi$.
   (a) Sketch a side view and rear view of the rotor.
   (b) How much is the TPP inclined in the fore and aft direction? Forward or backward?
   (c) How much is the TPP inclined laterally? Is the advancing or retreating blade high?
   (d) What angle does the blade make with the control plane at $\Phi = 0^0$, 90^0,180^0, 270^0,
   (e) At what azimuth angle is the flapping angle greatest?
   (f) What is the flapping angle at this point? [16]

7. (a) Explain the fundamental principle of autorotation. Also explain by means of blade element considerations why a rotor will auto rotate at many different combinations of blade pitch, rotor rpm, and disk angle of attack.

   (b) A helicopter uses the rotor for both lifting and propulsion, whereas the autogyro uses a propeller for propulsion. In terms of propulsive efficiency alone, is the helicopter or the autogiro a more efficient flight vehicle, and why? [8+8]

8. An understanding of "ground effect" is necessary to explain certain trends in helicopter behavior. Describe the mechanism of ground effect on hover. How does ground effect influence the performance of the helicopter during the transition from hover to forward flight? [16]

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Code No: 07A82104 | R07 | Set No. 4

IV B.Tech II Semester Examinations,APRIL 2011
HELICOPTER ENGINEERING
Aeronautical Engineering

Time: 3 hours | Max Marks: 80

Answer any FIVE Questions
All Questions carry equal marks
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1. (a) Explain the limitations of hovercraft on land and water.
   (b) Briefly explain the applications of hovercraft. [8+8]

2. (a) What do you understand by the term "NOTAR"? Describe one such system.
   (b) Discuss ways and means to avoid a tail rotor in balancing the rotor torque in a helicopter. How far are these concepts successful? [8+8]

3. (a) Describe the different parts of helicopters of single rotor configuration with the help of neat sketches.
   (b) Configure helicopters based up on torque reaction. [8+8]

4. The downstream wake from the rotor hub can often affect the unsteady loads on the tail rotor and empennage, to the extent that adverse lateral airframe forces can be produced. Suggest at least two techniques that could be adopted to alleviate this problem. [16]

5. Derive expressions for the mean coning angle, β_0 of a hovering rotor blade that has a uniform mass per unit length m and a concentrated mass M at its tip. Zero hinge offset can be assumed. Assume that the thrust on the blade varies linearly with radius. [16]

6. Describe the procedure a pilot would follow if the engine of a single engine helicopter failed in hover. How might the procedure differ if:
   (a) Two engines were installed and one engine failed,
   (b) The tail rotor failed. Estimate the auto-rotative rates of descent of three substantially different (in terms of gross weight) single-rotor helicopters of your choosing. Comment on your results. [16]

7. When testing a new airfoil section for helicopter applications, the lift variation at $M_\infty = 0.4$ shows an abrupt break at an AoA of 13.5^0. What static stall mechanism may be displayed by this airfoil? Describe the various steps that would be taken to confirm the stall type. [16]

8. Discuss the factors that limit the maximum forward speed capabilities of an autogyro. Do you think that the autogyro could be designed to have a cruise speed that is substantially faster than a helicopter? [16]

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Code No: 07A82104 **R07** **Set No. 1**

IV B.Tech II Semester Examinations,APRIL 2011
HELICOPTER ENGINEERING
Aeronautical Engineering

Time: 3 hours **Max Marks: 80**

Answer any FIVE Questions
All Questions carry equal marks

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1. Discuss in detail the reasons why the modern helicopter is still essentially a low-speed aircraft. Discuss how a main rotor system might be designed so that a helicopter can achieve higher overall forward flight speed and a possible expansion of the maneuvering envelope. Identify any potential trade-offs with any design option. [16]

2. (a) What are the limitations of ideal actuator disc theory applied to helicopter rotors? How are these remedied and to what extent, in the Blade Element theory?
   (b) How does the 'Blade Element Theory' become superior to the 'Actuator Disc Theory'? Hence define
      i. Thrust coefficient and
      ii. Torque coefficient. [8+8]

3. What are the limitations of a Hovercraft? At the same time what are the advantages/merits of such vehicle on land and water. [16]

4. The development of the autogyro clearly formed the basis for the design of the modern helicopter. Yet, the autogyro has been much less of a commercial success than the helicopter. Discuss the relative merits of the helicopter versus the autogyro from the standpoint of maximum speed capability, cruise efficiency, capital costs and maintenance costs. [16]

5. Explain the physical design features that distinguish a helicopter from an autogyro. Discuss the reasons as to why the autogiro was quickly eclipsed by the success of the helicopter when it appeared in the early 1940s. [16]

6. Sketch a representative total power curve for a helicopter in forward flight at sea level. Draw and label the breakdown of the constituent parts comprising this power curve, and explain the source of each part. Show also how you can use this type of power required curve (at a given altitude and gross weight) to determine: the vertical rate of climb, the speed for maximum endurance, the speed for maximum range, the maximum forward speed, and the maximum rate of climb in forward flight. [16]

7. (a) What are the principal details of a 'Hovercraft'. How does it obtain forward motion?
   (b) Explain the different types of hovercrafts with suitable diagrams. [8+8]

8. In a coaxial rotor design, the rotors are spaced sufficiently far apart such that the lower rotor operates in the fully developed slipstream of the upper rotor. Show that by means of the momentum theory and on the basis of equal torque (power) that the induced power factor resulting from interference is 1.22 compared to 1.41 when the rotors have no vertical separation. [16]

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Code No: 07A82104 **R07** **Set No. 3**

IV B.Tech II Semester Examinations,APRIL 2011
HELICOPTER ENGINEERING
Aeronautical Engineering

Time: 3 hours **Max Marks: 80**

Answer any FIVE Questions
All Questions carry equal marks

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1. (a) Demonstrate that part of the helicopter rotor that remains stalled in forward flight. Make use of sketches.
   (b) What makes a helicopter statically stable in longitudinal direction? Is it dynamically stable as well? [8+8]

2. (a) Describe VTOL action of Harrier airplane.
   (b) Describe the following terms with respect to helicopter:
      i. Vertical control.
      ii. Directional control. [8+8]

3. (a) Illustrate performance curves of a helicopter rotor with the effect of attitude.
   (b) Write a note on the directional stability/ Instability of a single rotor helicopter. [8+8]

4. In the design of a swept tip rotor blade, it is desired to introduce only as much sweepback as necessary to keep the Mach number incident to the leading-edge of the blade equal to a constant, say M_c, over the tip region. In addition, the location of the 1/4 chord axis of the blade is to be moved forward by a value e_R =0.02 at the point of sweep initiations so as to minimize the torsional moments on the blade that would be associated with the sweepback. Based on 2-D strip considerations, calculate and show the resulting blade geometry for a design advance ratio of 0.5. Assume that the critical azimuth angle for the design is taken to be at ψ=90^0, and that $M_{\Omega R} = 0.65$ and M_c=0.8. [16]

5. Derive the power calculations for plenum chamber and peripheral jet machines. [16]

6. For a truly heavy lift helicopter, say in excess of 100,000 kg gross takeoff weight, a single rotor design would be considered impractical. Discuss the reasons why this might be so. [16]

7. A helicopter is flying along with its physical shaft aligned with the tip path plane axis. The angle of attack of the rotor is 10^0 and the longitudinal flapping angle is 5^0. Assume that the flapping hinges are located on the rotational axis. Determine:
   (a) The value of the longitudinal cyclic pitch required to maintain this flight condition,
   (b) The inclination of the rotor shaft with respect to the vertical and

(c) The longitudinal flapping with respect to the rotor shaft. [16]

8. Using the momentum analysis for an overlapping rotor configuration with unequal rotor thrusts, find an expression for the overlap induced power factor κ_{OV} in terms of the overlap area $A_{OV} = m'A$ where

$$m' = \frac{2}{\pi}\left[\cos^{-1}\left(\frac{d}{D}\right) - \left(\frac{d}{D}\right)\sqrt{1-\left(\frac{d}{D}\right)^2}\right]$$

And where the rotors are assumed to have no vertical spacing. Assume that the total system thrust is expressed as $2T = \tau T_1 + (2-\tau)T_2$. Plot the results as a function of horizontal rotor separation distance d/D for several values of τ, and comment on the results. [16]

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