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# MANIPAL INSTITUTE OF TECHNOLOGY

MANIPAL

*A Constituent Institution of Manipal University*

## VII SEMESTER B.TECH. (AERONAUTICAL ENGINEERING)

## END SEMESTER EXAMINATIONS, JAN 2021

SUB: HELICOPTER AERODYNAMICS [AAE 4102]

**REVISED CREDIT SYSTEM**
**(27/01/2021)**

Time: 3 Hours MAX. MARKS: 50

**Instructions to Candidates:**

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

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| **1A.** | What do you mean by helicopter autorotation? Explain how it works. | **(2)** |
| **1B.** | What will be the percentage increase in the thrust coefficient of a rotor with blade tip-loss factor of 0.93, when the number of blades is increased from 2 to 3? | **(3)** |
| **1C.** | If the tip loss factor of helicopter is given 0.8, determine the induced power and climb power, assuming sea level density. Take helicopter rotor radius 6m rotating at 225 rpm at 6 m/s, when the thrust coefficient is 0.005. | **(5)** |
| **2A.** | Discuss the physical significance of helicopter anti-torque system. | **(2)** |
| **2B.** | Derive the expression for profile drag power and parasitic power. | **(3)** |
| **2C.** | A helicopter of gross weight ‘W’ with rotor diameter ‘D’, hovers at sea level achieving a figure of merit ‘M’. Using momentum theory, calculate the percentage decrease/increase in actual rotor power at 1 km above sea level at same ‘M’. Density ratio change of 8% per km may be assumed near seal level. | **(5)** |
| **3A.** | Explain the following helicopter parts: (i) Teetering Hinge (ii) Flapping hinge | **(2)** |
| **3B.** | With the help of neat diagrams explain the helicopter pilot controls. | **(3)** |
| **3C.** | Determine the power in hovering in sea level, if the tip loss factor is 0.96. Assume the helicopter of mass 1100 kg with the three bladed rotor of radius 5.4 m and blade chord 330 mm, rotates at 244 rpm has a profile drag coefficient of 0.008. | **(5)** |
| **4A.** | List all the distribution of power losses of the helicopter rotor in hover. | **(2)** |
| **4B.** | Explain the different types of helicopter rotor systems. | **(3)** |
| **4C.** | Determine the induced velocity, power to be supplied to the rotor while climbing and power rate of the helicopter. Take the helicopter of mass 1100 kg and rotor radius 600 cm steadily climbs at 2.3 m/s at sea level. If the rotor is rotating at 219.91 radians/sec and the actual power measured in hover 125 hp. | **(5)** |

**5A.** Describe the Gessow- Myers and Sissingh empirical tip loss factor based on helicopter rotor blade geometry. **(2)**

**5B.** Derive the expression for profile power coefficient using Bennet approximation. **(3)**

**5C.** A helicopter rotor with three blades, 10.8 m rotor diameter 33 cm constant chord, rotating at 300 rom is capable of just hovering at sea level with al up weight of 1500 kg or vertical climb (at sea level) with all up weight of 1200 kg. Find the rate of climb, if the blade airfoil profile drag is given as $C_{d_o} = 0.008 + 0.006C_l^2$ . **(5)**