Reg. No.										

MANIPAL INSTITUTE OF TECHNOLOGY

MANIPAL

A Constituent Institution of Manipal University

VII SEMESTER B.TECH. (AERONAUTICAL ENGINEERING)

END SEMESTER EXAMINATIONS, NOV / DEC 2018

SUB: HELICOPTER AERODYNAMICS [AAE 4102]

REVISED CREDIT SYSTEM
(27/12/2018)

Time: 3 Hours MAX. MARKS: 50

Instructions to Candidates:

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

1A. Discuss the swash plate mechanism used in helicopter rotor system. **(2)**

1B. Define the following terms: (i) Feathering (ii) Flapping and (iii) Lead-lag. **(3)**

1C. Write the assumptions of momentum theory. With the help of neat line diagram also derive the 'induced velocity' term using momentum theory. **(5)**

2A. Define the terms power loading and figure merit. **(2)**

2B. Explain the types of rotor systems used in the Helicopters. **(3)**

2C. A helicopter with a gross weight of 1363.3kg, a main rotor radius of 4m, a rotor tip speed of 207.3 m/s and has 205 kW delivered to the main rotor shaft. For hovering conditions at sea level, compute (a) the rotor disk loading, (b) the ideal power loading, (c) the thrust and torque coefficients, and (d) the figure of merit (FM) and actual power loading. **(5)**

3A. Analyse the optimum rotor Vs Ideal rotor concepts. **(4)**

3B. For a hovering helicopter with coaxial rotors, estimate the hovering horsepower required and the pitch settings for the rotor blades if Chord of the blade=0.635m, Radius of the blade=4.699m, Number of blades=4, Total thrust = 2948.35kg, RPM of the rotor =300, $\theta=\theta_{tip}/\bar{r}$ (ideal twist), Profile drag coefficient Cd_0 =0.012 (independent of Angle of Attack), Lift curve slope (a) = 5.73 per radian. Neglect slip stream contractions in calculating rotor interference effects **(6)**

4A. Using the fundamental equations derive the expression for power needed in climb and hover conditions. **(4)**

4B. A tilt-rotor has a gross weight of 25,000 kg. The rotor diameter is 12m. On the basis of the simple momentum theory, estimate the power required for the helicopter to hover at sea level on a standard day. Assume that the figure of merit of the rotors is 0.80 and transmission losses to 5%. If each of the two turbo-shaft engine delivers 4500 kW, estimate the maximum vertical rate if climb at sea-level **(6)**

5A. Explain the total power required in forward flight. **(4)**

5B. Derive the expression for power required for the forward flight using momentum analysis. **(6)**