Reg. No.										

MANIPAL INSTITUTE OF TECHNOLOGY

MANIPAL

(A constituent unit of MAHE, Manipal)

VII SEMESTER B.TECH. (AERONAUTICAL ENGINEERING)

END SEMESTER EXAMINATIONS, NOV 2019

SUB: HELICOPTER AERODYNAMICS [AAE 4102]

REVISED CREDIT SYSTEM
(21 /11/2019)

Time: 3 Hours MAX. MARKS: 50

Instructions to Candidates:

- Answer **ALL** the questions.
- Missing data may be suitable assumed.
- Draw the diagrams only with the 'PENCIL'.

1A. Describe the early fundamental technical problems associated with helicopters. **(2)**

1B. With the help of neat diagrams explain different controls of Helicopter. **(3)**

1C. A helicopter of rotor radius 6m rotating at 225 rpm climbs at 6 m/sec, when the thrust coefficient is 0.05. If the tip-loss factor is 0.8, determine the induced power and climb power, assuming sea level density. **(5)**

2A. Write the concept of 'Droop' associated with Helicopters. **(2)**

2B. A helicopter rotor is rotating at 250 rpm with influence angle of 4^0. If the angle of incidence at 70 percent distance from blade root end is 3^0, determine the thrust coefficient treating the local angle of incidence as the representative angle of attack; assume that the blades are without twist. **(3)**

2C. With the help of neat diagram derive the 'momentum theory' and also write its conclusions. **(5)**

3A. Draw the aerodynamic environment of a helicopter rotor blade with suitable notations and symbols. **(2)**

3B. Derive thrust approximation of Blade Element Theory (BET) for a given pitch angle of helicopter. **(3)**

3C. A helicopter of mass 1100 kg with three bladed rotor of radius 5.4 m and blade chord 33 cm, rotates at 244 rpm has a profile drag coefficient of 0.008, determine the power in hovering in sea level, if the tip loss factor is 0.96. **(5)**

4A. Write the non-dimensional form of following parameters using suitable notations (i) Thrust (ii) Torque (iii) Power and (iv) Inflow ratio. **(2)**

4B. With the help of neat diagrams derive the inflow velocity and the thrust generated by helicopter rotor using combined blade element momentum theory. **(3)**

4C. A helicopter weighs 4460 kg and has a rotor of 6.1 m radius, rotating at 320rpm. The blade solidity is 5 percent. The helicopter may be assumed to have an equivalent flat plate area of 1.4 m^2. (For calculating parasite drag of fuselage etc.). The mean profile drag coefficient is 0.01. (i) Estimate the total shaft power required for level forward flight at 130 km/hour at sea level. (b) Find how much extra power would be required if a climb rate of 200 m/minute has to be achieved at same forward speed and altitude. **(5)**

5A. Draw the forces on helicopter rotor blade element in autorotation condition. **(2)**

5B. Derive the profile power coefficient with and without radial flow terms. **(3)**

5C. A Preliminary design of a tandem rotor helicopter with a gross weight of 8655.2kg suggests a rotor diameter of 13.52 m, a blade chord of 0.408 m, three blades, and a rotor tip speed of 213.43 m/s. Estimate the total shaft power required to hover if the induced power factor for the front rotor is 1.20 and that for the rear rotor is 1.15. The rotor airfoil to be used has a zero lift drag coefficient of 0.01. Estimate the installed power if transmission losses amount to 5% and the helicopter must demonstrate a vertical rate of climb of 304.9 m/min at sea level. **(5)**