Reg. No.										

MANIPAL INSTITUTE OF TECHNOLOGY
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VII SEMESTER B.TECH. (AERONAUTICAL ENGINEERING)

END SEMESTER EXAMINATIONS, NOV / DEC 2018

SUB: HELICOPTER AERODYNAMICS [AAE 4102]

REVISED CREDIT SYSTEM
(24/11/2018)

Time: 3 Hours MAX. MARKS: 50

Instructions to Candidates:

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

1A. Write the differences between Dual rotor and Coaxial rotor systems. **(2)**

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

1C. A single rotor aircraft gross thrust of 30,250 lbf, ρ = 0.0023769 slug / cu.c.ft, rotor radius 19ft. There is 5 % transmission loss. Find out power supplied by the engine to the shaft. Take figure of merit 0.75. **(5)**

2A. Show the terms 'Thrust' and 'Power' coefficient used in momentum theory. **(2)**

2B. For a given number of blades (B) with an assumption of uniform inflow derive the tip losses expression in hovering flight condition. **(3)**

2C. A helicopter with a gross weight of 1867.3kg, a main rotor radius of 4m, a rotor tip speed of 205.3 m/s and has 200 kW delivered to the main rotor shaft. For hovering conditions at sea level, The tail rotor radius is 0.701m and the tail rotor is located 4.66m from the main rotor shaft. Calculate the thrust and power required by the tail rotor for hovering conditions at sea level. Assume that the FM of the tail rotor is 0.65 **(5)**

3A. Discuss the four drawbacks of Blade Element Theory (BET). **(2)**

3B. Analyze the Torque / Power approximation using Blade Element Theory (BET). **(3)**

3C. Consider a rotor craft with the following data: Weight of the rotor craft = $1.33*10^4$ N; Rotor radius = 4.88 m; Rotor disk area = 74.7m^2; Rotor tip speed = 213 m/s; Rotor blade chord = 0.3048 m; Number of blades = 2; Blade profile drag coefficient =0.01; Lift curve slope (a) = 6; Assume that inflow is uniform $\lambda_H=(\upsilon_H/\Omega R)$; Take atmospheric density and pressure at sea level, ρ_∞=1.225 kg/m^3; $P_\infty=1.013*10^5$ N/m^2. Find: (a) Find the non-dimensional pressure change $(\Delta P/P_\infty)$ across the rotor disk. (b) Find the value of the induced velocity far below the rotor. (c) Find the thrust coefficient C_T. (d) Find the local lift coefficient at r=0.5*R (e) Find the local blade pitch angle at r=0.5*R, in degrees. (f) Find the ratio of profile power coefficient to the induced power coefficient **(5)**

4A. With the help of neat diagrams explain (i) Vortex ring state (ii) Turbulent wake state (iii) Wind mill brake state. **(4)**

4B. A Preliminary design of a tandem rotor helicopter with a gross weight of 8800.2 kg suggests a rotor diameter of 14.72 m, a blade chord of 0.508 m, three blades, and a rotor tip speed of 215.43 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. **(6)**

5A. Derive the detailed evaluation of profile power with and without the radial flow terms. **(4)**

5B. A helicopter is operating in level forward flight at 210 ft/sec under the following conditions: shaft power supplied = 655 hp; Weight = 6000 lbs. The rotor parameters are: R = 19 feet; Solidity = 0.08; Tip speed = 700 ft/sec; Induced drag correction factor (k) = 1.15; Profile drag coefficient = 0.01. (i) How much power is required to overcome induced losses (ii) How much power is required to overcome profile power losses (iii) what is the equivalent-flat-plate area, f? (iv) If the installed power is 800 hp, estimate the maximum rate of climb possible at this airspeed **(6)**