Reg. No.										

MANIPAL INSTITUTE OF TECHNOLOGY

MANIPAL

(A constituent unit of MAHE, Manipal)

SECOND SEMESTER M.TECH. (AEROSPACE ENGINEERING)

END SEMESTER EXAMINATIONS, MAY/JUNE 2018

SUBJECT: FLIGHT MECHANICS [ICE 5202]

Time: 3 Hours MAX. MARKS: 50

Instructions to Candidates:

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

1A. Derive the force equations for aircraft motion in the body axis system. **5**

1B. Describe earth axis to body axis transformation with neat diagrams. **3**

1C. An aircraft model T-37 is executing the loop at the following conditions: **2**

Euler angles: $\psi = 0$ deg., $\theta = 30$ deg, $\phi = 0$ deg

The pilot observes a pure pitch rate at a constant velocity in the body axis system:

$$\vec{\omega}_B = \begin{bmatrix} 0 \\ 0.1 \\ 0 \end{bmatrix}_B rad/s \quad \vec{V}_B = \begin{bmatrix} 200 \\ 0 \\ 0 \end{bmatrix}_B ft/s$$

What is the acceleration in the Earth-fixed reference system?

2A. What do you mean by aircraft specific endurance? Derive average value endurance equation and Breguet endurance equation. **A T-37** aircraft model at **20000 ft.** has a drag polar $\boldsymbol{C_D = 0.02 + 0.057C_L^2}$. The aircraft has an initial weight of 6000 lb. and 500 lb. of usable fuel. If the TSFC at sea level is 0.9/h, find the maximum endurance. **5**

2B. Derive the expression for turn rate and turn radius for an aircraft in a level turn. Determine the load factor, bank angle and turn radius for an aircraft in a level turn at a true airspeed for 120 km and turn rate of 15 deg/s. **3**

2C. Derive an expression for an aircraft's rate of climb. **2**

3A. Find the expressions for glide range and rate of descent for an aircraft. Also comments on the condition to maximize the rate of descent. **5**

3B. The following data apply to a turbojet aircraft: $\boldsymbol{C_D = 0.02 + 0.057C_L^2}$**;** Initial weight = **6000** $\boldsymbol{lb}$**,** $\boldsymbol{S = 184\ ft^2}$*;* ***TSFC*** **=** $\boldsymbol{c}$ **= 1.25=** $\boldsymbol{h}$ at sea level and $\rho = 0.008907$. Find the range for this jet at **30000 ft** if the pilot is flying for max range and has **1000 lb** of fuel available. **3**

3C. An aircraft has a **20-kn** headwind and would like a **200-kn** ground speed. If the aircraft is flying at **10,000** ft (standard day), what indicated airspeed should it fly if the position error is **-1** kn? **2**

Note**:** $\boldsymbol{f}$ factor=0.995, $\rho = 0.00176$, $\rho_{SL} = 0.00238$

4A. Describe trim conditions and stability requirements for longitudinal static stability of an aircraft. **5**

4B. How to estimate aircraft pitching moment coefficient C_m using first order Taylor series expansion? Illustrate briefly. **3**

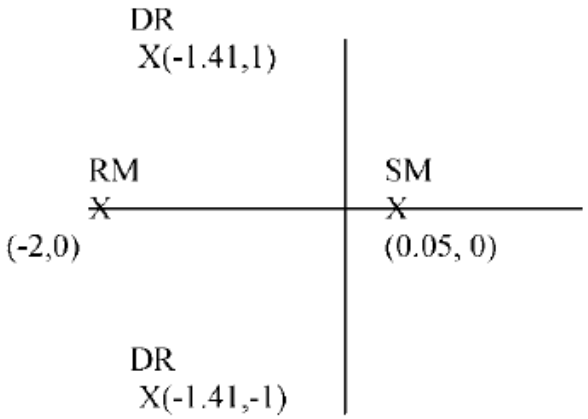
4C. Derive an expression for C_{mC_L} in terms of static margin, noting that $C_{mC_L} = \frac{\partial C_m}{\partial C_L}$. **2**

5A. What do you mean by short period and phugoid natural frequencies? The following is the longitudinal characteristics equation for an F-89 Scorpion flying at 20000 ft. at Mach 0.638. **5**

$$(s^2 + 4.2102s + 18.2329)(s^2 + 0.00899s + 0.003969) = 0$$

Determine the short period and phugoid natural frequencies.

5B. Given the location of the following roots on the complex plane, **3**



Determine the time constant for the dutch roll (DR), spiral mode (SM) and roll mode (RM). Also determine the natural frequency and damping ratio of the dutch roll mode.

5C. For the following given equation **2**

$$\ddot{X} + 1.8\,\dot{X} + 9X = 9,$$

What is the solution at t=0.3s?

****