Reg. No.										

MANIPAL INSTITUTE OF TECHNOLOGY
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A Constituent Institution of Manipal University

V SEMESTER B.TECH. (AERONAUTICAL ENGINEERING)

END SEMESTER EXAMINATIONS, NOV/DEC 2017

SUBJECT: FLIGHT DYNAMICS [AAE 3101]

REVISED CREDIT SYSTEM
(19/12/2017)

Time: 3 Hours MAX. MARKS: 50

Instructions to Candidates:

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

1A. Lateral perturbation equation of motion for Boeing 747 in horizontal at $\mathbf{40,000\,ft}$ height, forward speed of $\mathbf{774\,ft/s}$, Mach $\mathbf{0.8}$ with rudder chosen as actuator is given as: **(07)**

$$\begin{bmatrix}\dot{\beta}\\ \dot{\gamma}\\ \dot{\rho}\\ \dot{\phi}\end{bmatrix} = \begin{bmatrix}-0.254 & 0 & -1.0 & 0.182\\ -16.02 & -8.40 & 2.19 & 0\\ 4.488 & -0.350 & -0.760 & 0\\ 0 & 1 & 0 & 0\end{bmatrix}\begin{bmatrix}\beta\\ \gamma\\ \rho\\ \phi\end{bmatrix} + \begin{bmatrix}0.00729\\ -0.475\\ 0.153\\ 0\end{bmatrix}\begin{bmatrix}\delta_A\\ \delta_R\end{bmatrix}$$

Find the open loop poles. Identify all the modes of the aircraft and calculate the time constants, damped frequencies, damping ratios and discuss stability.

1B. Explain why the conventional wing-fuselage combination with a vertical canard mounted at the nose of the fuselage is always directionally stable. **(03)**

2A. The full longitudinal characteristic equation for the Learjet 24 flying at $\mathbf{0.}7$ Mach and $\mathbf{40,000\,ft}$ cruise flight conditions is given by **(07)**

$$170.62\,S^4 + 305.72\,S^3 + 435.07S^2 + 29.87S + 23.14 = 0$$

$$Z_\alpha = -103.516, M_q = 0.817, M_\alpha = -1.94, M_{\dot{\alpha}} = -0.3047, V_{P_1} = 677\frac{ft}{sec}, C_{D_u} = 0, C_{T_{x_1}} = 0.256, C_{L_1} = 1.64$$

Show the percentage error in the values of natural frequency and damping ratios from associated exact roots and by approximations.

2B. Mach tuck derivative C_{m_u} is affected by two important parameters in flight. Discuss? **(03)**

3A. Find the state space representation of the transfer function given below and also draw the bock diagram of the system. **(07)**

$$\frac{y(s)}{u(s)} = \frac{K}{S^4 + 4S^3 + 6S^2 + 3S + 2}$$

3B. How do position of wing has an influence on C_{l_β} from design point of view? **(03)**

4A. What is windmilling effect? How do you explain the rolling moment resulting from an asymmetric thrust in right engine out condition in both jet and propeller configurations? **(07)**

4B. What is the condition which holds true when there is reduction of magnitude of C_{n_β}, due to flow separation over the wings? **(03)**

5A. Determine the aileron and rudder deflections required for a phantom-5 aircraft to maintain a $+2$ degree wings level sideslip at 0.6 Mach and $30000\,ft$. Determine the value of side-force coefficient under these conditions. Applicable derivatives are: **(07)**

$C_{y_0} = 0$	$C_{y_\beta} = -0.9056/rad$	$C_{y_{\delta_A}} = -0.0047/rad$	$C_{y_{\delta_R}} = 0.1492/rad$
$C_{l_0} = 0$	$C_{l_\beta} = -0.0732/rad$	$C_{l_{\delta_A}} = 0.0226/rad$	$C_{l_{\delta_R}} = 0.0029/rad$
$C_{n_0} = 0$	$C_{n_\beta} = 0.1638/rad$	$C_{n_{\delta_A}} = 0.0026/rad$	$C_{n_{\delta_R}} = -0.0712/rad$

5B. Explain how the differentially deflected stabilizers in fighter jets generate a rolling moment. **(03)**