Reg. No.										

Manipal Institute of Technology, Manipal

(A Constituent Institute of Manipal University)

VI SEMESTER B.TECH (AERONAUTICAL ENGINEERING)

END SEMESTER EXAMINATIONS, MAY 2016

SUBJECT: FLIGHT DYNAMICS [AAE 306]

REVISED CREDIT SYSTEM

Time: 3 Hours. MAX.MARKS: 50

Instructions to Candidates:

- Answer **ANY FIVE FULL** questions.
- Missing data may be suitably assumed.

1A. A T-37 has the following stability derivative values during a no-flap final approach at 100 $knots$ equivalent airspeed: **(05)**

C_{l_β}	$-0.11/deg$	$C_{l_{\delta_R}}$	$0.0172/deg$
C_{n_β}	$0.127/deg$	$C_{l_{\delta_A}}$	$0.178/deg$
$C_{n_{\delta_R}}$	$-0.0747/deg$	$C_{n_{\delta_A}}$	$-0.0172/deg$

Assume that the pilot lands with the fuselage aligned with the runway. With $\delta_{R_{max}} = \pm 15^0$ and $\delta_{A_{max}} = \pm 10^0$, what is the maximum crosswind component allowable and which is the limiting control (aileron or rudder)?

1B. Give the physical explanation for the aerodynamic mechanism responsible for $C_{Y_{P_V}}$ derivative with proper illustration. **(03)**

1C. Estimate the pitching damping derivative, C_{m_q}, for an aircraft with the following characteristics: $C_{L_{\alpha_h}} = 0.075/deg$, $\eta_h = 0.98, \overline{V}_h = 0.375$, $(X_h/\bar{c}) = 3.0$ **(02)**

2A. The perturbation equation of motion for A-4 Skyhawk airplane in horizontal flight at 50,000 ft height, forward speed of 774 ft/sec, mach no. 0.8 with rudder chosen as actuator is given as: **(05)**

$$\begin{bmatrix} \dot{\beta} \\ \dot{\gamma} \\ \dot{\rho} \\ \dot{\emptyset} \end{bmatrix} = \begin{bmatrix} -0.248 & 0 & -1.0 & 0.072 \\ -23.0 & -1.68 & 0.808 & 0 \\ 13.5 & -0.0356 & -0.589 & 0 \\ 0 & 1 & 0 & 0 \end{bmatrix} \begin{bmatrix} \beta \\ \gamma \\ \rho \\ \emptyset \end{bmatrix} + \begin{bmatrix} 0.00729 \\ -0.475 \\ 0.153 \\ 0 \end{bmatrix} \begin{bmatrix} \delta_a \\ \delta_r \end{bmatrix}$$

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

2B. Explain how the differentially deflected stabilizers in fighter jets generate rolling moment? **(03)**

2C. With negative I_{XZ} for an aircraft, what does the equation $\boldsymbol{P^2 I_{XZ} = -I_{YY}\dot{Q}}$ Indicates? **(02)**

3A. For a given aircraft at a given flight condition, the numerical expression for the characteristic equation is **(05)**

$$\boldsymbol{877\,S^4 + 1109\,S^3 + 7097\,S^2 - 4.966\,S - 11.42}$$

a) Check the stability criteria using the Routh-Hurwitz Criterion.
b) Verify the stability by solving the expression and comment on stability.
c) Comment on why the aircraft is stable or unstable.

3B. What is a windmill effect? How would you explain the rolling moment resulting from an asymmetric thrust in right engine out condition in both jet and propeller configurations? **(03)**

3C. Does the moment coefficient C_m accounts for the aero elastic effects on the aircraft? **(02)**

4A. The full longitudinal characteristic equation for the Cessna T37 aircraft at cruise flight conditions is given by ($\boldsymbol{Z_\alpha = -437.4, M_q = -2.477, M_\alpha = -19.4, M_{\dot{\alpha}} = -1.1553, V_{p_1} = 456\frac{ft}{sec}, C_{D_u} = 0, C_{T_{X_u}} = -0.07, C_{L_1} = 0.378}$) **(05)**

$$\boldsymbol{457\,S^4 + 2107\,S^3 + 9917\,S^2 + 117.3\,S + 88.23}$$

Find the percentage error in the values of natural frequency and dampening ratio from associated roots (True baseline values) and by approximations for short period mode phugoid mode.

4B. When a fuselage is added to the wing, there is an effect on the aerodynamic center of wing plus fuselage. Explain this effect of fuselage on aerodynamic center (Munk Effect)? **(03)**

4C. What is the physical significance of having a $'s'$ in the heading transfer function in Lateral directional dynamics? **(02)**

5A. Suppose an airplane is constrained to a pure yawing motion ($\Delta \boldsymbol{r}$) characterized by the following equation: **(05)**

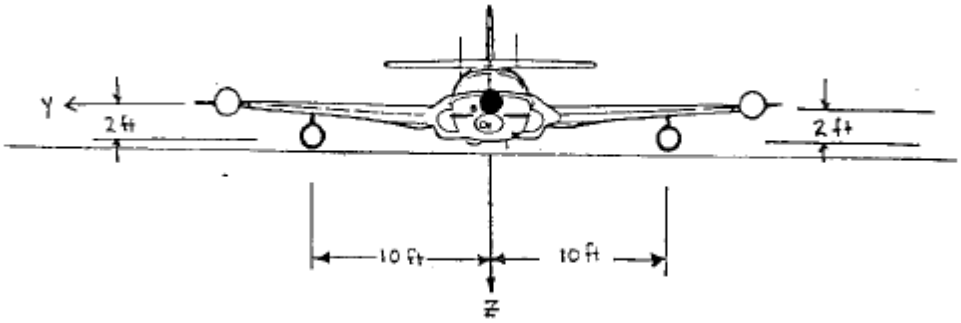
$$\boldsymbol{\Delta\ddot{\psi} = -0.76\,\Delta\dot{\psi} - 4.55\Delta\psi - 4.6\Delta\delta_R}$$

a) Write the yawing moment equation in state space.
b) The characteristic equation and eigenvalues of the system.
c) Comment on system behavior and find damping ratio and undamped natural frequency.

5B. Which sideslip derivative has an influence on Dutch roll dynamics and why? **(03)**

5C. If the aircraft C.G. is located aft of the neutral point, the aircraft is stable or unstable longitudinally? **(02)**

6A. An A-37 is loaded with two $500\ lb$ bombs as shown. The distances of the bombs from the aircraft center of gravity are shown. What happens to I_{xx} if both bombs are dropped? What is the value of the change in I_{xx}? **(05)**



6B. In analyzing the quasi steady derivatives, why there is greater tendency for positive side force to be developed at the right wing tip as the flow migrates from lower to upper low pressure surface? **(03)**

6C. Find the moment derivative of $\dot{\alpha}\bar{c}/2U_1$ for the F-4C aircraft at the conditions given at $35,000\ ft$ and $mach\ 0.9$, $U_1 = 876\ ft$, $\bar{q} = 283.2\ lb/ft^2$, $S = 530\ ft^2$, $\bar{c} = 16\ ft, C_{m_{\dot{\alpha}}} = -1.3\ per\ rad$. If $\dot{\alpha} = 0.5\ deg/s$, find the perturbed pitching moment m_A. **(02)**