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, DEC 2016/JAN 2017

SUBJECT: FLIGHT DYNAMICS [AAE 3101]

REVISED CREDIT SYSTEM
(27/12/2016)

Time: 3 Hours MAX. MARKS: 50

Instructions to Candidates:

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

1A. If $\Delta\alpha = \frac{py}{u_0}$ is the local angle of attack for an aircraft in roll, $'b'$ is the wing span, prove that the estimated roll damping derivative due to wing surface is (05)

$$C_{l_p} = \frac{-4C_{L_\alpha}}{Sb^2}\int_0^{b/2} cy^2\,dy$$

1B. What happens when the net lift acting at the airplane neutral point exerts a larger down-pitching moment at the airplane CG due to shift of neutral point aft in supersonic flight? (03)

1C. Do you think that C_{Z_α} and C_{X_α} have a significant effect on the short period eigenmotion as well as the phugoid motion? (02)

2A. 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? Write the two possible solutions to overcome it? (05)

2B. Answer the following: (03)

a) What can be the solution to generate yawing moment in response to pilot's command if the airplane is without vertical tail?
b) How can we make the magnitude of $C_{n_{\delta_R}}$ larger?

2C. What is the relationship between natural frequency and the undamped frequency for any eigenmotion? (02)

3A. The state-space equations in matrix form for LTV A-7A Corsair aircraft are given as (05)

$$\begin{bmatrix} \dot{u} \\ \dot{w} \\ \dot{q} \\ \dot{\theta} \end{bmatrix} = \begin{bmatrix} 0.005 & 0.00464 & -73 & -31.34 \\ -0.086 & -0.545 & 309 & -7.4 \\ 0.00185 & -0.00767 & -0.395 & 0.00132 \\ 0 & 0 & 1 & 0 \end{bmatrix} \begin{bmatrix} u \\ w \\ q \\ \theta \end{bmatrix} + \begin{bmatrix} 5.63 \\ -23.8 \\ -4.52 \\ 0 \end{bmatrix} [\delta]$$

At the flight condition 4.57 km (15kft) and Mach 0.3, obtain the eigen values, frequency responses for all the variables and observe the discerning effects in the dynamics.

3B. How can you prove that downwash angle $\boldsymbol{\varepsilon}$ is a function of angle of attack $\boldsymbol{\alpha}$? (03)

3C. Is it true, if an aircraft is symmetric about the xz-plane then $\boldsymbol{I_{XY}}$ and $\boldsymbol{I_{XZ}}$ are zero. (02)

4A. Sketch the root locus of the longitudinal transfer function of a general aviation plane as (05)

$$\boldsymbol{G(s)H(s) = \frac{k(s+3)}{s(s+10)(s^2+8s+20)}}$$

4B. A T 37 is in a steady level turn. Sensors on the aircraft measure the following accelerations and rates (03)

$$U = 200\frac{ft}{s} \quad \dot{U} = 5\frac{ft}{s^2} \quad P = 0\frac{rad}{s}, Q = 0.1\frac{rad}{s} \quad R = 0.1\frac{rad}{s}$$
$$V = 0\frac{ft}{s} \quad W = 10\frac{ft}{s} \quad \dot{V} = 0\,\frac{ft}{s^2} \quad \dot{W} = 0\frac{ft}{s^2}\ .$$

Find the T 37's inertial acceleration vector in the body axis.

4C. What is first metacenter in longitudinal static stability? (02)

5A. The lateral–directional characteristic equation for the Douglas DC-8 aircraft in a low altitude cruise flight condition, is (05)

$$\boldsymbol{\Delta(s) = s^4 + 1.326s^3 + 1.219s^2 + 1.096s - 0.015 = 0}$$

a) Inspect the characteristic equation above for stability using Routh-Hurwitz criterion.
b) Verify the stability by solving the characteristic equation.

5B. The following data are given for a large transport airplane (wing– body plus tail configuration) flying at a speed V = 100 m/s at sea level. Consider wing details as follows: (03)

$$C_{L_0} = 0.5, S = 300\ m^2, b = 60m, C_{L_\alpha} = 4.44\ rad^{-1}$$

The tail is unswept of planform area $S_t = 0.1\,S$ made up of a symmetric airfoil section and is set at an angle $i_t = 3^0$ with respect to the reference axis

of the aircraft. This reference axis measures the relative wind at an angle of attack, 15°. The tail lift curve slope can be approximated as

$$C_{L_\alpha}{}^t = 2\pi\ rad^{-1}\ and\ \alpha_t = \alpha - i_t - \varepsilon$$

Show that the ratio of tail lift to the lift produced at the wing is 0.045.

5C. What do you call a center of gravity position, at which the equilibrium of the moment is neutrally stable, stick fixed? (02)