U.S.N.										

B.M.S. College of Engineering, Bengaluru-560019

Autonomous Institute Affiliated to VTU

June 2025 Semester End Main Examinations

Programme: B.E. **Semester: VI**
Branch: Aerospace Engineering **Duration: 3 hrs.**
Course Code: 23AS6PCFLD / 22AS6PCFLD **Max Marks: 100**
Course: Flight Dynamics

Instructions: 1. Answer any FIVE full questions, choosing one full question from each unit.
2. Missing data, if any, may be suitably assumed.

Important Note: Completing your answers, compulsorily draw diagonal cross lines on the remaining blank pages. Revealing of identification, appeal to evaluator will be treated as malpractice.

			CO	PO	Marks
		UNIT - I			
1	a)	Derive the three moment equations of motion (with necessary assumptions) in the Body-Axis system of an aircraft, starting from the angular momentum equation $\vec{H} = I\,\vec{\omega}$, where I is the Inertia tensor and ω is the angular velocity.	CO1	PO1	**10**
	b)	Derive the kinematic equations of motion.	CO1	PO1	**10**
		OR			
2	a)	Consider the T-37 at the following Euler angles: Yaw angle Ψ = +90°, Pitch angle Θ = +10° and Roll angle Φ = +10° Describe the aircraft attitude and transform the weight force through these angles to the body axis system. The gross weight is 30 kN.	CO1	PO2	**05**
	b)	Describe the Earth axis system.	CO1	PO1	**05**
	c)	Draw the vector diagram for the stability axis system of an aircraft and convert it into the body axis system in terms of the aerodynamic forces.	CO1	PO1	**10**
		UNIT - II			
3	a)	Show that the derivative due to the changes in the forward speed in the x-direction with respect to u/U_1 is dependent on the speed damping derivative and the coefficient of aerodynamic drag under steady state condition by deriving a relation.	CO2	PO1	**10**
	b)	Find the u/U_1 derivative for the F-4C aircraft at 10,500 m and Mach 0.9 (U_1 = 267 m/s, q = 13, 560 N/m^2, S = 50 m^2) if C_{D_1} = 0.03 and C_{D_u} = 0.027. If U is perturbed to 268 m/s, find the perturbed applied aero force along the x stability axis (f_{A_x}).	CO2	PO2	**05**
	c)	Show that the derivative due to the changes in the forward speed is dependent on the Mach-Tuck derivative and the coefficient of moment under steady state condition by deriving a relation.	CO2	PO1	**05**

			OR			
	4	a)	Linearize and simplify based on the assumptions and the choice of body-fixed stability axis during the perturbed flight for the given aircraft's longitudinal equation of motion. $$m(\dot{W} + PV - QU) = mg\cos\Phi\cos\Theta + F_{A_z} + F_{T_z}$$	*CO2*	*PO1*	**10**
		b)	Assume a Lear Jet is cruising (level, unaccelerated flight) at 12,000 m (density of air = 0.310828 kg/m^3) with U_1 = 207 m/s, S = 22 m^2, Weight = 57,827 N, and C_{Tx1} = 0.0335. Find C_{L1}, C_{D1} and the thrust.	*CO2*	*PO2*	**10**
			UNIT - III			
	5		Derive the expression for stability derivatives due to the rolling rate.	*CO3*	*PO1*	**20**
			OR			
	6	a)	Derive the expression for stability derivatives due to the yaw rate.	*CO3*	*PO1*	**15**
		b)	Illustrate the influence of yaw rate on velocity distribution on the wing and tail with a neat sketch.			**05**
			UNIT - IV			
	7	a)	Find the natural frequency and the damping ratio based on the two degree of freedom Phugoid approximation given by the standard equation below. $$\begin{bmatrix} s - X_u & X_\alpha & g \\ -Z_u & s(U - Z_{\dot{\alpha}}) - Z_\alpha & -(Z_q + U_1)s \\ M_u & (M_{\dot{\alpha}}s + M_\alpha) & s^2 - M_q s \end{bmatrix} \begin{bmatrix} \frac{U(s)}{\delta_e s} \\ \frac{\alpha(s)}{\delta_e s} \\ \frac{\theta(s)}{\delta_e s} \end{bmatrix} = \begin{bmatrix} X_{\delta_e} \\ Z_{\delta_e} \\ M_{\delta_e} \end{bmatrix}$$	*CO3*	*PO1*	**10**
		b)	Find the natural frequency (ω_n), the damping ratio (ζ) damped frequency (ω_d) from the characteristic equation given below: $$s^2 + 0.0062s + 0.8979$$	*CO3*	*PO2*	**05**
		c)	Split the polynomial equation into two characteristic equations of degree two and explain which one belongs to short-period and phugoid motion. $$s^4 + 4.5898s^3 + 21.6536s^2 + 0.2204s + 0.1879$$	*CO3*	*PO2*	**05**
			OR			
	8	a)	Find the natural frequency of the phugoid as a slow interchange of kinetic energy and potential energy with the necessary assumptions from the Lanchester model.	*CO3*	*PO1*	**10**
		b)	The following is the longitudinal characteristic equation for an F-89 Scorpion flying at 6,096 m at Mach 0.638. Determine the short period and phugoid natural frequencies, as well as the damping ratios and damped frequencies for both modes: $$(s^2 + 4.2102s + 18.2329)(s^2 + 0.00899s + 0.003969) = 0$$	*CO3*	*PO2*	**10**

			UNIT - V			
	9	a)	Explain autorotation with the necessary combined coefficient of lift (C_L) and coefficient of drag (C_D) versus the angle of attack (α).	*CO3*	*PO1*	**14**
		b)	Explain spin and derive the radius for the same.	*CO3*	*PO1*	**06**
			OR			
	10	a)	Explain Dutch roll.	*CO3*	*PO1*	**10**
		b)	Explain spiral instability.	*CO3*	*PO1*	**10**

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