U.S.N.										

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

Autonomous Institute Affiliated to VTU

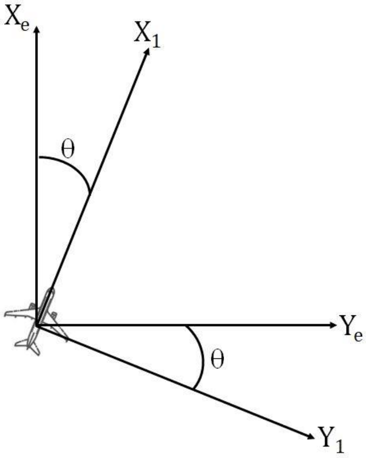
June 2025 Semester End Main Examinations

Programme: B.E. **Semester: VI**
Branch: Aerospace Engineering **Duration: 3 hrs.**
Course Code: 20AE6DCDSM **Max Marks: 100**
Course: Flight Dynamics and Space Mechanics

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.

		UNIT - I	*CO*	*PO*	**Marks**
1	a)	Write down the accepted limits on Euler angles. Convert the coordinate of the position vector in the Earth axis system defined by $$\vec{F_E} = x_E\hat{\imath}_E + y_E\hat{\jmath}_E + z_E\hat{k}_E$$ to the body axis system $(\vec{F_B})$ based on the accepted sequence of Euler angles with possible vector diagrams.	*CO1*	*PO1*	**10**
	b)	Given the following vectors, find the inertial acceleration in the body axis system: $$\vec{a_t} = \dot{\vec{V_B}} + \omega \times \vec{V_B}$$ $\dot{\vec{V_B}} = \begin{Bmatrix} 3 \\ 0 \\ 0 \end{Bmatrix}_B m/s^2$, $\vec{V_B} = \begin{Bmatrix} 0 \\ 0 \\ 0.3 \end{Bmatrix}_B rad/s$ and $\vec{V_B} = \begin{Bmatrix} 100 \\ 0 \\ 0 \end{Bmatrix}_B m/s$	*CO1*	*PO2*	**05**
	c)	Consider the T-37 at the following Euler angles: Yaw angles Ψ = +90°, Pitch angle Θ = +10° and Roll angle ø = +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**
		OR			
2	a)	The transformation from the axes system 1 is given by $$E_1 = TE_e$$	*CO1*	*PO2*	**05**

			 The transformation matrix T can be derived by expressing the unit vectors of system 1 in terms of the unit vectors of system e. Derive the expression for the transformation matrix.			
		b)	A T-37 is executing a loop under the following conditions: Euler angles: Yaw angles Ψ = 0°, Pitch angle Θ = +30° and Roll angle Ø = 0° The pilot observes the pure pitch rate at a constant velocity in the body axis system $\overrightarrow{\omega_B} = \begin{Bmatrix} 0 \\ 0.1 \\ 0 \end{Bmatrix}_B \; rad/s$ and $\overrightarrow{V_B} = \begin{Bmatrix} 60 \\ 0 \\ 0 \end{Bmatrix}_B \; m/s$ What is the acceleration in the earth-fixed reference system?	*CO1*	*PO2*	**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)	Linearize the kinematic equation of motion $P = -\sin\Theta\dot{\Psi} + \dot{\Phi}$.	*CO2*	*PO2*	**08**
		b)	Show that the derivative due to the changes in the forward speed in the x-direction with respect to u/U1 is dependent on the speed damping derivative and the coefficient of aerodynamic drag under steady-state conditions by deriving a relation.	*CO2*	*PO1*	**12**
			OR			
	4	a)	Show that the derivative due to the change of angle of attack in the z-direction with respect to $\hat{\alpha}$ is dependent on the lift-curve slope and the coefficient of aerodynamic drag under steady-state conditions by deriving a relation.	*CO2*	*PO1*	**10**
		b)	Find the $\hat{\alpha}$derivative $\frac{\partial F_{A_z}}{\partial \hat{\alpha}}$ for the F-4C aircraft at the same flight conditions as those of the prior problem in which C_{L_α} = 3.75 /rad. If the F-4C is trimmed at an angle of attack of 2.6⁰ and then is perturbed to 3.1⁰, find the perturbed aero force along the z-stability axis (F_{A_z}).	*CO2*	*PO2*	**10**

			UNIT - III			
	5	a)	Illustrate the influence of yaw rate on velocity distribution on the wing and tail with a neat sketch.	*CO3*	*PO1*	**05**
		b)	Derive the expression for stability derivatives due to the yaw rate.	*CO3*	*PO1*	**15**
			OR			
	6		Derive the expression for stability derivatives due to the rolling rate.	*CO3*	*PO1*	**20**
			UNIT - IV			
	7	a)	Find the natural frequency and the damping ratio based on the two degree of-freedom short period approximation given by the standard equation below. $$\begin{bmatrix} s - X_u & X_\alpha & g \\ -Z_u & s(U - Z_{\dot\alpha}) - Z_\alpha & -(Z_q + U_1)s \\ M_u & (M_{\dot\alpha}s + M_\alpha) & s^2 - M_q s \end{bmatrix} \begin{bmatrix} \frac{U(s)}{\delta_e s} \\ \frac{\alpha(s)}{\delta_e s} \\ \frac{\theta(s)}{\delta_e s} \end{bmatrix} = \begin{bmatrix} X_{\delta_e} \\ Z_{\delta_e} \\ M_{\delta_e} \end{bmatrix}$$	*CO4*	*PO1*	**10**
		b)	Explain autorotation in aircraft with respect to the lift and drag curve.	*CO4*	*PO1*	**10**
			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.	*CO4*	*PO1*	**10**
		b)	The α/δe transfer function for a T-37 cruising at 9,000 m and 0.46 Mach is given below by the equation. Find the natural frequency, damping ratio, damped frequency, and time constant for the short period and phugoid modes. $$\frac{\alpha}{\delta_e} = \frac{(S + 336.1)(s^2 + 0.0105s + 0.0097)}{s^4 + 4.5898s^3 + 21.6536s^2 + 0.2204s + 0.1879}$$	*CO4*	*PO2*	**10**
			UNIT - V			
	9	a)	Prove that $r_o = \frac{L^2}{GMm^2}$ and $e^2 = 1 + \frac{2Er_o}{GMm}$ in an ellipse. Where ro is the semi-latus rectum.	*CO5*	*PO1*	**10**
		b)	An earth satellite is in an orbit with perigee altitude z_p = 400 km and an eccentricity e = 0.6. Find (i) the perigee velocity (ii) the apogee radius (iii) the semimajor axis (iv) the apogee velocity (v) the period of the orbit. (μ = 3,98,600 km^3/s^2 and the radius of the earth R = 6378 km)	*CO5*	*PO2*	**10**
			OR			
	10	a)	State and prove Kepler's First law of planetary motion.	*CO5*	*PO1*	**10**
		b)	State and derive Kepler's third law of planetary motion.	*CO5*	*PO1*	**05**
		c)	Derive the equation for gravitational potential energy.	*CO5*	*PO1*	**05**

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