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

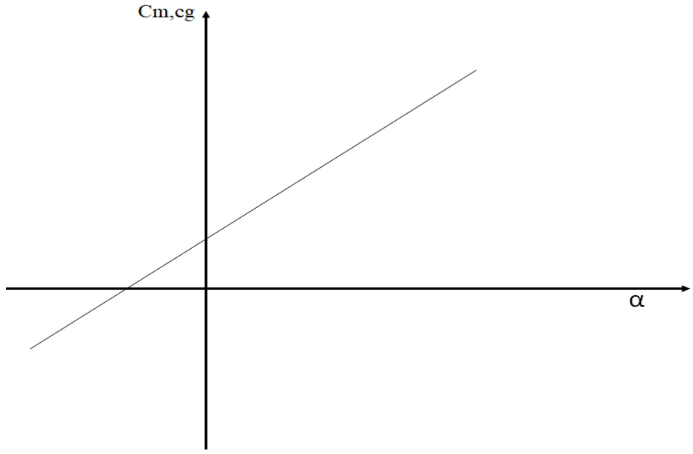
Autonomous Institute Affiliated to VTU

June / July 2025 Semester End Main Examinations

Programme: B.E. **Semester: V**
Branch: AEROSPACE ENGINEERING **Duration: 3 hrs.**
Course Code: 23AS5PCBFM / 22AS5PCBFM **Max Marks: 100**
Course: BASIC FLIGHT MECHANICS

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

			UNIT - I	*CO*	*PO*	Marks
	1	a)	Prove that $C_{D,o} = \frac{1}{3} C_{D,i}$ for the thrust required based on static equilibrium conditions described by the aerodynamic forces and how does this condition is related to the aerodynamic efficiency is compared with the minimum thrust required on a thrust required curve. Also, derive the aerodynamic efficiency for both cases. Here, $C_{D,o}$ is the parasite drag at zero-lift and $C_{D,i}$ is the lift-induced drag.	*CO1*	*PO2*	**10**
		b)	Show that the rate of climb of an airplane is the ratio of excess power to its weight.	*CO1*	*PO1*	**5**
		c)	A jet-powered executive aircraft having the following characteristics Wingspan = 10.919 m, Wing area S = 16.16 m^2, Normal gross weight = 13138.533 N. Parasite Drag co-efficient = 0.025 and Oswald efficiency factor e = 0.8 with V_∞ = 50 m/s. Calculate the thrust required.	*CO1*	*PO2*	**5**
			OR			
	2	a)	Define Range and Endurance. Explain the quantitative considerations for deriving a propeller airplane's range and endurance. How the range and endurance can be maximized?	*CO1*	*PO2*	**10**
		b)	Consider an airplane with mass 2268 kg, planform area 9.29 m^2, parasite drag coefficient at zero lift 0.015, Oswald's efficiency factor 0.6 and aspect ratio 6. The velocity at the sea level is 152.4 m/s, then calculate the coefficient of drag (i) if the airplane is in level flight and (ii) if the same airplane is in 30° climb with the same velocity. Write the conclusions and discussion about the coefficient of lift, coefficient of drag and the aerodynamic efficiency in both the cases.	*CO1*	*PO1*	**07**
		c)	Why can stalling speed not be reached in a level, steady flight?	*CO1*	*PO1*	**03**

			UNIT - II			
	3	a)	Write the formulae for the distance required along the ground during take-off and draw the force diagram based on aerodynamic and frictional force parameters.	*CO1*	*PO1*	**05**
		b)	Derive the equation for the distance required for landing and integrate the equation where the limits vary from touch down velocity to zero.	*CO1*	*PO2*	**15**
			OR			
	4	a)	Estimate the lift-off distance for the Jet powered airplane (CJ-1) at sea level with mass 8987.93 kg, wingspan 16.25 m, wing area 29.54 m^2 with zero-lift parasite drag co-efficient is 0.02 having a thrust of 32,472 N and the Oswald's efficiency factor is 0.81. Assume a paved runway having $\boldsymbol{\mu}_r$ = 0.02. Also, during the ground roll, the angle of attack of the airplane is restricted by the requirement that the tail not drag the ground, and therefore, assume that C_{Lmax} during the ground roll is limited to 1.0. Also, when the airplane is on the ground, the wings are 1.83 m above the ground. [Note: The average force is calculated based on Shevell's suggestion of being equal to 0.7 V_{LO} which is considered as the freestream velocity].	*CO1*	*PO2*	**10**
		b)	Derive the equation for the gyroscopic couple with necessary explanations, when the disc is rotating in the counter-clockwise direction with constant angular velocity when viewed from the front by summing up the components in the direction and perpendicular to the direction of spin.	*CO2*	*PO2*	**10**
			UNIT - III			
	5	a)	How many degrees of freedom does an aircraft have? What are they? Explain the control surfaces of an aircraft with its location and their control over the motion.	*CO3*	*PO2*	**5**
		b)	Is the airplane having $C_{m,cg}$ vs α graph as shown in the figure 5 b), controllable and flyable? Justify.  Figure 5(b): $C_{m,cg}$ versus α	*CO3*	*PO2*	**5**

		c)	A wing-body model is tested in a subsonic wind tunnel. The lift is found to be zero at a geometric angle of attack $\alpha = -1.5^o$. At $\alpha = 5^o$ the lift co-efficient is measured as 0.52. Also, at $\alpha = 1.0^o$ and 7.88^o, the moment coefficient about the center of gravity are measured as -0.01 and 0.05, respectively. The center of gravity is located at 0.35c from the leading edge. Calculate the location of the aerodynamic center and the value of $C_{M,acwb}$.	*CO3*	*PO2*	**10**
			OR			
	6	a)	State the criteria for longitudinal static stability of an aircraft from the illustration of static stability and instability.	*CO3*	*PO2*	**15**
		b)	Describe and derive the moments about the center of gravity due to tail only.	*CO3*	*PO2*	**5**
			UNIT - IV			
	7		Explain how the elevator helps in changing the value of $C_{M,0}$ and hence changing the trimmed angle of attack for different flight speeds.	*CO3*	*PO2*	**20**
			OR			
	8		Describe the illustration of aerodynamic moment of elevator-hinge moment and the factors that produce it and hence derive the equation for the free elevator factor.	*CO3*	*PO2*	**20**
			UNIT - V			
	9	a)	Describe the applications of helicopter.	*CO3*	*PO1*	**05**
		b)	Derive an expression for the ratio of induced to hovering velocity through axial-climb momentum analysis.	*CO3*	*PO2*	**15**
			OR			
	10		Derive an expression for the effect of induced velocity in forward flight.	*CO3*	*PO2*	**20**

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