U.S.N.										

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

Autonomous Institute Affiliated to VTU

January / February 2025 Semester End Main Examinations

Programme: B.E. **Semester: V**
Branch: Aerospace Engineering **Duration: 3 hrs.**
Course Code: 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.

			CO	PO	Marks
		UNIT - I			
1	a)	Define pressure drag, skin-friction drag and lift-induced drag.	CO1	PO1	**05**
	b)	Prove that $C_{D,o} = \frac{1}{3} C_{D,i}$ for the power required for level, unaccelerated flight.	CO1	PO1	**10**
	c)	Consider the Northrop F-5 fighter airplane, which has a wing area of 16 m^2 and a wing span of 7.7 m. The wing is generating 80,068 N of lift. For a flight velocity of 112 m/s at standard sea-level, calculate the lift coefficient, induced drag coefficient, and the induced drag. (Assume e = 0.8)	CO1	PO2	**05**
		OR			
2	a)	Describe and derive both the range and endurance for a propeller airplane from the physical and quantitative considerations.	CO1	PO2	**20**
		UNIT - II			
3	a)	Write the formulae for the distance travelled along the ground during take-off and landing and draw the graphs of force versus distance along the ground based on aerodynamic and frictional force parameters.	CO1	PO1	**10**
	b)	Estimate the landing ground roll distance at sea level for the Jet powered aircraft (CJ-1) whose mass is 5603 kg with wing area 29.54 m^2. The zero-lift drag co-efficient is 0.02. No thrust reversal is used; however, spoilers are employed such that L=0. The spoilers increase the zero-lift drag-coefficient by 10 percent. The fuel tanks are essentially empty, so neglect the weight of any fuel carried by the airplane. The maximum lift co-efficient, with flaps fully employed at touchdown is 2.5 and the co-efficient of rolling friction is 0.4.	CO1	PO2	**10**
		OR			

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.

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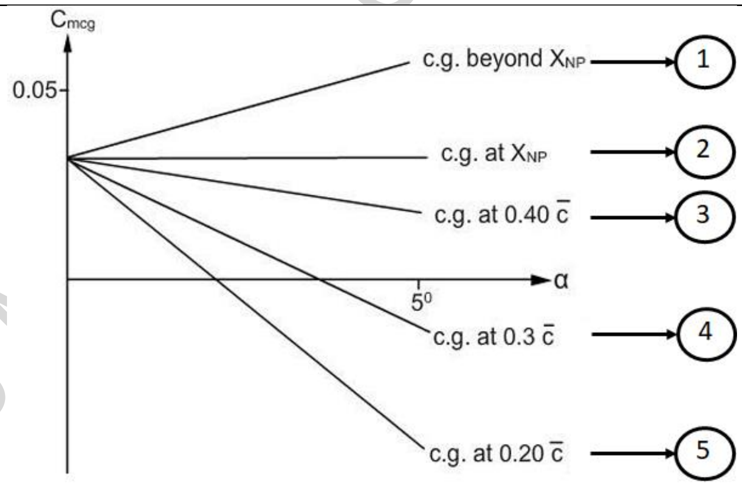
<table>
<tr><td></td><td>4</td><td>a)</td><td>Derive the equation for the gyroscopic couple with necessary explanations, when the disc is rotating in the counter-clockwise direction with constant angular velocity when viewed from the front.</td><td>*CO2*</td><td>*PO1*</td><td>**10**</td></tr>
<tr><td></td><td></td><td>b)</td><td>An uniform disc of diameter 300 mm and of mass 5 kg is mounted on one end of an arm of length 600 mm. The other end of the arm is free to rotate in a universal bearing. If the disc rotates about the arm with a speed of 300 r.p.m. clockwise, looking from the front, with what speed will it precess about the vertical axis?</td><td>*CO2*</td><td>*PO2*</td><td>**6**</td></tr>
<tr><td></td><td></td><td>c)</td><td>Define: (i) active gyroscopic couple and (ii) reactive gyroscopic couple</td><td></td><td></td><td>**04**</td></tr>
<tr><td></td><td></td><td></td><td>**UNIT - III**</td><td></td><td></td><td></td></tr>
<tr><td></td><td>5</td><td>a)</td><td>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. What are the forces and moments that contributes to the pitching moment about the center of gravity?</td><td>*CO3*</td><td>*PO1*</td><td>**05**</td></tr>
<tr><td></td><td></td><td>b)</td><td>Enumerate the differences between the static and dynamic stability.</td><td>*CO3*</td><td>*PO2*</td><td>**05**</td></tr>
<tr><td></td><td></td><td>c)</td><td>The contribution of wing fuselage combination to the moment about the c.g. of an airplane is given in the table below.
<table><tr><td>C_L</td><td>0.28</td><td>0.488</td><td>0.696</td></tr><tr><td>(Cmcg)w,f</td><td>-0.0216</td><td>-0.006</td><td>0.0064</td></tr></table>
If the wing loading is 850 N/m^2, find the flight velocity at sea level when the airplane is in trim with zero lift on the tail.</td><td>*CO3*</td><td>*PO2*</td><td>**05**</td></tr>
<tr><td></td><td></td><td>d)</td><td>

Figure: 5(d) $C_{m,cg}$ vs α

From the figure 5(d) mention the numbers 1 to 5 as stable, unstable and neutrally stable.</td><td>*CO3*</td><td>*PO2*</td><td>**05**</td></tr>
<tr><td></td><td></td><td></td><td>**OR**</td><td></td><td></td><td></td></tr>
<tr><td></td><td>6</td><td>a)</td><td>Prove that the neutral point is the aerodynamic center of the complete airplane.</td><td>*CO3*</td><td>*PO1*</td><td>**05**</td></tr>
<tr><td></td><td></td><td>b)</td><td>Show that the static margin is a direct measure of longitudinal static instability.</td><td>*CO3*</td><td>*PO1*</td><td>**05**</td></tr>
</table>

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		c)	Describe and derive the moments about the center of gravity due to wing-tail combination.	*CO3*	*PO1*	**10**
			UNIT - IV			
	7	a)	Explain how the elevator helps in changing the value of C_{M0} and hence changing the trimmed angle of attack for different flight speeds.	*CO3*	*PO1*	**20**
			OR			
	8	a)	Prove that the elevator angle to trim is $$\delta_{trim} = \frac{\frac{\partial C_{M,cg}}{\partial \alpha}\alpha + C_{M,o}}{V_H \frac{\partial C_{L,t}}{\partial \delta_e}}$$	*CO3*	*PO1*	**10**
		b)	What are the factors that produces aerodynamic hinge moment on the elevator? Explain.	*CO3*	*PO1*	**10**
			UNIT - V			
	9	a)	Enumerate the differences between the fixed wing aircraft and the rotor wing aircraft.	*CO3*	*PO1*	**05**
		b)	A helicopter has the following data: Gross weight =1363.6 kg Main rotor radius = 4.0 m Rotor tip speed = 207.3 m/s Rotor Power = 205 kW For hovering conditions at sea level, compute the following: (i) Rotor disk loading, (ii) Ideal Power loading, (iii) Thrust, Torque and Power coefficients, (iv) Figure of merit and actual power loading.	*CO3*	*PO2*	**10**
		c)	A tilt rotor has a gross weight of 25,400 kg. The rotor diameter is 12 m. On the basis of momentum theory, estimate the power required for the helicopter to hover at the sea level conditions. Assume that the figure of merit of the rotor is 0.8 and the transmission losses ≈ 5%.	*CO3*	*PO2*	**05**
			OR			
	10	a)	An inventor claims to have built a “flying car” that can hover, where the lifting force is provided by two ducted fans. The car weighs 1000 kg and has a 149.14 kW engine. The unducted fans are 2.13 m in diameter. Is hovering flight possible? [Hint:A ducted fan can be considered to have an effective area that is twice that of an unducted rotor.]	*CO3*	*PO2*	**05**
		b)	Derive an expression for the effect of induced velocity in hovering flight.	*CO3*	*PO1*	**10**
		c)	Draw and list the parts of helicopter.	*CO3*	*PO1*	**05**

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