Hall Ticket No | | | | | | | | | | | Question Paper Code: AAEB13

INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)
Dundigal, Hyderabad - 500 043

MODEL QUESTION PAPER - I

B.Tech V Semester End Examinations, November - 2020
Regulations: R18
AIRCRAFT STABILITY AND CONTROL
(Aeronautical Engineering)

Time: 3 hours **Max. Marks: 70**

Answer ONE Question from each Unit
All Questions Carry Equal Marks
All parts of the question must be answered in one place only

MODULE – I

1.	a)	Show with diagram about positive elevator deflection, and rudder deflection and in this condition what will be the attitude of the airplane?	**[7M]**
	b)	Illustrate the body axis coordinate system of an airplane and list down the forces, moments and velocity components of an airplane and also show them on the sketch.	**[7M]**
2.	a)	If $C_M = +C_{M\alpha}$. ; What will the value of C_{Mo} for cambered and symmetrical airfoil. Also explain the values for positive and negative camber airfoils.	**[7M]**
	b)	During flight, it was observed that rudder got fixed 3 degree right. Explain, how the pilot will handle this condition? Show with diagram.	**[7M]**

MODULE– II

3.	a)	Illustrate the condition for static directional stability by stating mathematical equation applicable.	**[7M]**
	b)	During flight, it was observed that left aileron got fixed 3 degree down. Explain, how the pilot will handle this condition? Show with force and moment diagram.	**[7M]**
4.	a)	Enumerate the effects of vertical tail on directional stability. Some aircrafts having two or more vertical tail. Give the advantages and disadvantages of single and multi-vertical tail.	**[7M]**
	b)	Draw the plots of C_m vs α and C_L Vs α showing the effects of elevator deflections in positive and negative direction. Demonstrate the effects of elevator deflection on the angle of attack of the tail plane.	**[7M]**

MODULE – III

5. a) Demonstrate with a suitable diagram of yaw rotation while Earth to Body axis transformation. **[7M]**

   b) A rudder deflection of 30 deg produces a stable sideslip angle of 50 deg. Estimate $Cn_{\beta,wf}$. Neglect Downwash, use $\eta_v = 1$, $CL\alpha,v = .1$ deg−1, Sr /St = 0.6 and $V_v = 0$ .8. **[7M]**

6. a) Demonstrate inertial frame of reference with suitable sketch. In which frame of reference Newton's laws of motion are valid? **[7M]**

   b) Express all forces (weight, aerodynamic, and thrust) for sea level at military thrust in most convenient axis system. Assume the thrust lines are parallel to the longitudinal axis and in plane of CG. The aircraft weighs 24.5 kN and each engine is delivering 3.11kN thrust. **[7M]**

MODULE – IV

7. a) Demonstrate the primary control power with suitable mathematical expression. It is also referred as Elevator control power. Why? **[7M]**

   b) Solve u/U_1 derivative for an aircraft at 1.0668 km and Mach 0.9 ($U_{1=}$ 267 m/s, q= 1383 kg/m^2, S=50m^2) if C_{D1} = 0.03 and C_{Du} = 0.027.If u is perturbed to 268,2 m/s, find the perturbed applied aero force along the x stability axis. **[7M]**

8. a) Illustrate the significance of perturbation of equation of motions. Why this is important in the dynamics analysis of the aircraft? **[7M]**

   b) Examine the pitch damping derivative, Cm_q, for an aircraft with following characteristics: $C_{L\alpha h} = 0.075$/deg, $\eta_h = 0.98$, $V_h = 0.375$, $(X_h/c) = 3.0$. Where c is mean chord length. **[7M]**

MODULE – V

9. a) What way the dynamic stability analysis of the airplane helps the design of control systems and the pilot who operates it? **[7M]**

   b) The lateral stability quadratic for an airplane is : **[7M]**

   $$\lambda 4+16\lambda 3+13.1\lambda 2+9.8\lambda+0.73=0$$

   Extract the roots of this quartic. Obtain the time to double or halve the amplitude and the period of the oscillatory mode.

10. a) What is meant by weather cocking effect? Explain with necessary diagram of this effect and the result of this. **[7M]**

    b) The roots of a longitudinal stability quartic are: 2.57 ± i 2.63; +0.02 and -0.26. Discuss the types of motions indicated by each mode. What would be the final motion of the airplane? **[7M]**

MAPPING OF COURSE OUTCOME WITH SEMESTER END EXAMINATION (SEE) QUESTION PAPER

COURSE OBJECTIVES:

The course should enable the students to:

I	al knowledge on static stability of aircraft in multiple directional motions with their critical applications in flight vehicles.
II	The aircraft equations of motion to correlate qualitatively with potential applications in aircraft stability in different degrees of freedom (DOF).
III	The methods of optimizing the aircraft equations of motion and its derivatives for aircraft dynamic stability in various flight modes.
IV	The utilization of advances of flight dynamics and control in design and development of modern airplane control systems.

COURSE OUTCOMES (COs):

After successful completion of the course, students should be able to:

CO 1	**Recall** the concept of static stability in longitudinal, lateral and directional modes to be used for different aircrafts stability conditions.
CO 2	**Describe** the state of an equilibrium, control and trim inputs required for an aircraft in static longitudinal and lateral directional stability.
CO 3	**Recognize** the aircraft components contributing to the stability of different aircraft models like Military, Civil and transport aircrafts.
CO 4	**Identify** stick fixed and stick free conditions for neutral points with an appropriate static margin, control force and CG limitation.
CO 5	**Interpret** the specific coupling between lateral and directional static stability of the aircraft and its influence on other motion of a typical aircraft.
CO 6	**Construct** the mathematical model of aircraft motion in longitudinal, lateral and directional cases for establishing the status of the flight vehicles stability.
CO 7	**Outline** the contribution of aircraft components and their influence on lateral and directional static stability on flight vehicles.
CO 8	**Analyze** different axis systems used for flight dynamics and their transformations from one system to another system.
CO 9	**Explain** qualitatively about motion in three-dimensions, Euler angles and rates, full 6-DOF equations for rigid symmetrical aircraft, state space formulation, and solution in the time domain and flight simulation.
CO 10	**Demonstrate** different stability derivatives used in stability and control problems in different degree of freedom of aircrafts using different computational and experimental tools.
CO 11	**Categorize** different types of dynamic modes in longitudinal, lateral and directional motion of the aircraft and their influence on dynamic stability and safety.
CO 12	**Apply** the advances of flight dynamics and controls in design of modern airplane control systems.

MAPPING OF SEMESTER END EXAMINATION QUESTIONS TO COURSE OUTCOMES

SEE Question No		Course Outcomes	Course Outcomes	Blooms Taxonomy Level
1	a	Show with diagram about positive elevator deflection, and rudder deflection and in this condition what will be the attitude of the airplane?	CO 1	Remember
	b	Illustrate the body axis coordinate system of an airplane and list down the forces, moments and velocity components of an airplane and also show them on the sketch.	CO 2	Understand
2	a	If $C_M = +C_{M\alpha.}$; What will the value of C_{Mo} for cambered and symmetrical airfoil. Also explain the values for positive and negative camber airfoils.	CO 1	Apply
	b	During flight, it was observed that rudder got fixed 3 degree right. Explain, how the pilot will handle this condition? Show with diagram.	CO 3	Apply
3	a	Illustrate the condition for static directional stability by stating mathematical equation applicable.	CO 4	Understand
	b	During flight, it was observed that left aileron got fixed 3 degree down. Explain, how the pilot will handle this condition? Show with force and moment diagram.	CO 3	Apply
4	a	Enumerate the effects of vertical tail on directional stability. Some aircrafts having two or more vertical tail. Give the advantages and disadvantages of single and multi-vertical tail.	CO 5	Understand
	b	Draw the plots of C_m vs α and C_L Vs α showing the effects of elevator deflections in positive and negative direction. Demonstrate the effects of elevator deflection on the angle of attack of the tail plane.	CO 6	Apply
5	a	Demonstrate with a suitable diagram of yaw rotation while Earth to Body axis transformation.	CO 8	Understand
	b	A rudder deflection of 30 deg produces a stable sideslip angle of 50 deg. Estimate $Cn_{\beta,wf}$. Neglect Downwash, use $\eta_v = 1$, $CL\alpha,v = .1$ deg−1, Sr /St = 0.6 and $V_v = 0$ .8.	CO 7	Apply
6	a	Demonstrate inertial frame of reference with suitable sketch. In which frame of reference Newton's laws of motion are valid?	CO 7	Understand
	b	Express all forces (weight, aerodynamic, and thrust) for sea level at military thrust in most convenient axis system. Assume the thrust lines are parallel to the longitudinal axis and in plane of CG. The aircraft weighs 24.5 kN and each engine is delivering 3.11kN thrust.	CO 8	Analyze
7	a	Demonstrate the primary control power with suitable mathematical expression. It is also referred as Elevator control power. Why?	CO 8	Understand
	b	Solve u/U_1 derivative for an aircraft at 1.0668 km and Mach 0.9 ($U_{1=}$ 267 m/s, q= 1383 kg/m^2, S=50m^2) if C_{D1} = 0.03 and C_{Du} = 0.027.If u is perturbed to 268,2 m/s, find the perturbed applied aero force along the x stability axis.	CO 10	Analyze
8	a	Illustrate the significance of perturbation of equation of motions. Why this is important in the dynamics analysis of the aircraft?	CO 9	Understand

	b	Examine the pitch damping derivative, Cm_q, for an aircraft with following characteristics: $C_{L\alpha h} = 0.075$/deg, $\eta_h = 0.98$, $V_h = 0.375$, $(X_h/c) = 3.0$. Where c is mean chord length.	CO 11	Apply
9	a	What way the dynamic stability analysis of the airplane helps the design of control systems and the pilot who operates it?	CO 10	Understand
	b	The lateral stability quadratic for an airplane is : $\lambda 4+16\lambda 3+13.1\lambda 2+9.8\lambda+0.73=0$ Extract the roots of this quartic. Obtain the time to double or halve the amplitude and the period of the oscillatory mode.	CO 12	Apply
10	a	What is meant by weather cocking effect? Explain with necessary diagram of this effect and the result of this.	CO 11	Understand
	b	The roots of a longitudinal stability quartic are: 2.57 ± i 2.63; +0.02 and -0.26. Discuss the types of motions indicated by each mode. What would be the final motion of the airplane?	CO 12	Apply

Signature of Course Coordinator **HOD, AE**