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: IARE - R18

AIRCRAFT STABILITY AND CONTROL

AERONAUTICAL ENGINEERING

Time: 3 hour | Maximum Marks: 70

Answer ONE Question from each MODULE
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_{m0} 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) 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**]

4. (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**]

MODULE-III

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

   (b) A rudder deflection of $\cong 30^0$ produces a stable sideslip angle of $\cong 50^0$. Estimate $C_{n\beta,wf}$. Neglect Downwash, use $\eta_\nu = 1, C_{L\alpha,\nu} = .1\ deg^{-1}$, $S_r/S_t = 0.6$ and $V_\nu = 0.8$. [**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 3.11 kN 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 $\frac{u}{U_1}$ derivative for an aircraft at $1.0668km$ and Mach 0.9 ($U_1 = 267m/s, q = 1383kg/m^2$, $S = 50m^2$) if $C_{D1} = 0.03$ and $C_{Du} = 0.027$.If u is perturbed to $268, 2m/s$, 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, C_{Mq}, for an aircraft with following characteristics: $C_{L\alpha h} = 0.075/deg, h = 0.98, V_h = 0.375, (X_h/c) = 3.0$. 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 : $\lambda^4 + 16\ \lambda^3 + \ 13.1\ \lambda^2 + 9.8\ \lambda\ + 0.73 = 0$ Extract the roots of this quartic. Obtain the time to double or halve the amplitude and the period of the oscillatory mode. [**7m**]

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:$2.57 \pm i2.63;\ +0.02$ and -0.26. Discuss the types of motions indicated by each mode. What would be the final motion of the airplane? [**7m**]

****END OF EXAMINATION****

COURSE OBJECTIVES:

The course should enable the students to:

1	The fundamental knowledge on static stability of aircraft in multiple directional motions with their relationship for critical applications in flight vehicles.
2	The methods of optimizing the aircraft equations of motion and its derivatives for aircraft dynamic stability in various flight modes.
3	The methods of optimizing the aircraft equations of motion and its derivatives for aircraft dynamic stability in various flight modes.
4	The utilization of advances of flight dynamics and control in design and development of modern airplane control systems.

COURSE OUTCOMES:

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

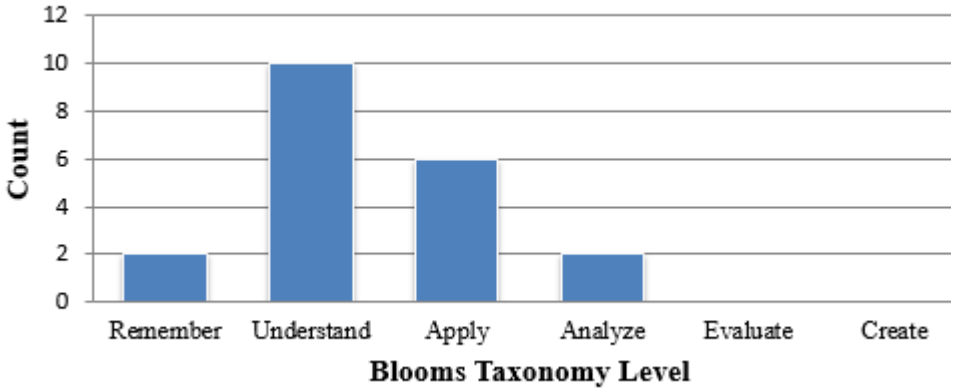
CO 1	Recall the concept of static stability in longitudinal, lateral and directional modes to be used for different aircrafts stability conditions.
CO 2	Describe the state of an equilibrium, control and trim inputs required for an aircraft in static longitudinal and lateral directional stability.
CO 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
CO8	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

Q.No		All Questions carry equal marks	Taxonomy	CO's	PO's
1	a	Show with diagram about positive elevator deflection, and rudder deflection and in this condition what will be the attitude of the airplane?	Remember	CO 1	PO 1
	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.	Understand	CO 2	PO 1
2	a	If $C_m = +C_{m\alpha}$: What will the value of C_{m0} for cambered and symmetrical airfoil. Also explain the values for positive and negative camber airfoils.	Apply	CO 1	PO 2
	b	During flight, it was observed that rudder got fixed 3 degree right. Explain, how the pilot will handle this condition? Show with diagram.	Understand	CO 3	PO 1
3	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.	Remember	CO 1	PO 1
	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.	Understand	CO 4	PO 1
4	a	Illustrate the condition for static directional stability by stating mathematical equation applicable.	Understand	CO 5	PO 1
	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.	Apply	CO 6	PO 1,2
5	a	Demonstrate with a suitable diagram of yaw rotation while Earth to Body axis transformation.	Understand	CO 8	PO 1
	b	A rudder deflection of $\cong 30^0$ produces a stable sideslip angle of $\cong 50^0$. Estimate $C_{n\beta,wf}$. Neglect Downwash, use $\eta_\nu = 1, C_{L\alpha,\nu} = .1$ deg^{-1}, $S_r/S_t = 0.6$ and $V_\nu = 0.8$.	Understand	CO 7	PO 2

6	a	Demonstrate inertial frame of reference with suitable sketch. In which frame of reference Newton's laws of motion are valid?	Understand	CO 7	PO 1
	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 3.11 kN thrust.	Analyze	CO 8	PO 2,4
7	a	Demonstrate the primary control power with suitable mathematical expression. It is also referred as Elevator control power. Why?	Understand	CO 8	PO 1
	b	Solve $\frac{u}{U_1}$ derivative for an aircraft at $1.0668km$ and Mach 0.9 ($U_1 = 267m/s, q = 1383kg/m^2$, $S = 50m^2$) if $C_{D1} = 0.03$ and $C_{Du} = 0.027$.If u is perturbed to $268, 2m/s$, find the perturbed applied aero force along the x stability axis.	Analyze	CO 10	PO 2,4
8	a	Illustrate the significance of perturbation of equation of motions. Why this is important in the dynamics analysis of the aircraft?	Understand	CO 9	PO 1
	b	Examine the pitch damping derivative, C_{Mq}, for an aircraft with following characteristics: $C_{L\alpha h} = 0.075/deg, h = 0.98, V_h = 0.375$, $(X_h/c) = 3.0$. Where c is mean chord length.	Apply	CO 11	PO 1,2
9	a	hat way the dynamic stability analysis of the airplane helps the design of control systems and the pilot who operates it?	Understand	CO 9	PO 1
	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.	Apply	CO 12	PO 1,2
10	a	What is meant by weather cocking effect? Explain with necessary diagram of this effect and the result of this.	Apply	CO 11	PO 1
	b	The roots of a longitudinal stability quartic are:$2.57 \pm i2.63;\ +0.02$ and -0.26. Discuss the types of motions indicated by each mode. What would be the final motion of the airplane?	Apply	CO 12	PO 2,4

KNOWLEDGE COMPETENCY LEVELS OF MODEL QUESTION PAPER



Signature of Course Coordinator **HOD, AE**
Dr. Yagya Dutta Dwivedi, Professor