AIRCRAFT STABILITY AND CONTROL

VI Semester: AE

Course Code	Category	Hours / Week			Credits	Maximum Marks		
		L	T	P	C	CIA	SEE	Total
AAEC24	Core	3	1	-	4	30	70	100
Contact Classes: 40	Tutorial Classes: 15	Practical Classes: Nil				Total Classes: 60		

Prerequisite: Knowledge of Aerodynamics/ Propulsion and Flight Mechanics

I. COURSE OVERVIEW:

Aircraft Stability and Control is the science that investigates the stability and control of aircrafts and all other flying vehicles. From the advent of the first flight by the Wright Brothers, it was observed that flight without knowledge of stability and control was not viable. Since then, several different concepts for controlling aircraft flight have been devised including control surfaces, deformable surfaces, morphing of wings etc. This course introduces some of these concepts and describes their operation, as well as the degree of stability that these devices can provide. Modern aircraft control is ensured through automatic control systems known as autopilot. Their role is to increase safety, facilitate the pilot's task and improve flight qualities. The course will introduce modern aircraft stability and control and discuss some of its objectives and applications.

II. COURSE OBJECTIVES:

The student will try to learn:

- **I** The fundamental knowledge on static stability of aircraft in multiple directional motions with their relationship for 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 anddevelopment of modern airplane control systems

III. COURSE OUTCOMES:

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

CO 1	**Identify** the concept of static stability in longitudinal, lateral anddirectional modes by using mathematical expression for different aircraft stability conditions.	Apply
CO 2	**Solve** the design problems of the airframe components considering the aircraft static stability by using stability criteriaequations and plots.	Apply
CO 3	**Make use of** the aircraft equations of motion in 6- degree of freedomand transform one axis to another axis system by using mathematical formulations for understanding the behavior in different flight maneuvers.	Apply
CO 4	**Develop** the procedure to linearization of equations of motion by usingperturbation theory for determining aerodynamic derivatives of the airplane.	Apply
CO 5	**Examine** the different types of dynamic modes in longitudinal, lateral and directional motion for the aircraft and their influence on dynamic stability and safety.	Analyze
CO 6	**Apply** the advance theories of flight dynamics in design of modern control airplane control systems for enhancing aircraft performance, Modern control systems and autopilot system.	Apply

IV. COURSE SYLLABUS:

MODULE-I: INTRODUCTION AND LONGITUDINAL STABILITY-I (11)

Aircraft axes system, Definition: Equilibrium, stability, controllability, & maneuverability. Examples from simple mechanical systems for stability. Longitudinal static stability and dynamic stability for un- accelerated flight. Criteria for longitudinal static stability and trim condition. Contribution of principle components on longitudinal stability. Equations of equilibrium- stick fixed neutral point, elevator angle required to trim. Definition-static margin. Equations of motion in steady state, symmetric pull-up maneuver. Elevator effectiveness, elevator hinge

moment, neutral point, maneuver point, static margin for stick fixed and stick free conditions, control force and control gradient. Trim tabs and types of trim tabs, aerodynamic and mass balancing of control surfaces, Most forward and aft limits of CG and neutral point. Numerical.

MODULE –II: LATERAL-DIRECTIONAL STATIC STABILITY (07)
Introduction to lateral-direction stability- aerodynamic forces and moments, aircraft side force due to side slip, aircraft rolling moment due to side slip, and aircraft yawing moment due to side slip. Aircraft component contribution for directional static stability, aircraft component contribution for lateral-directional stability, rudder requirements. Numerical.

MODULE –III: AIRCRAFT EQUATION OF MOTION (10)
Description of motion of flight vehicle - systems of reference frames - earth, body, wind, stability axes system, relative merits. Euler angles, angles of attack and sideslip angle - definitions - Earth to body axis transformation, stability axis to body axis transformation. Rotating axis system - expressions for linear and angular moment of rigid body, time derivatives-inertia tensor, components of linear and angular velocities, accelerations.

Components of aerodynamic, gravity forces, moments applied on flight vehicle. Equations of motion- longitudinal and lateral-directional (No derivation**).** Relation between angular velocity components and Euler angle rates. Determination of velocities of airplane in earth axis system. Numerical.

MODULE –IV: LINEARIZATION OF EQUATIONS OF MOTION AND AERODYNAMIC FORCES AND MOMENTS DERIVATIVES (09)
Description of state of motion of vehicle, forces and moments as perturbations over prescribed reference flight condition. Equation of motion in perturbation variables. Assumption of small perturbations, first order approximations-linearization equations of motion. Linearized of force and moment equation of motion**,** Linearized longitudinal and lateral-directional equations of perturbed motion. Significance of aerodynamic derivatives. Derivatives of axial, normal force components and pitching moment with respect to the velocity, angle of attack, angle of attack rate, pitch rate, elevator angle (No derivation only concept). Numerical.

MODULE –V: AIRCRAFT DYNAMIC STABILITY (09)
Principle modes of motion characteristics, mode shapes and significance, time constant, un-damped natural frequency and damping ratio- mode shapes- significance. One degree of freedom, two degree of freedom approximations- constant speed (short period), constant angle of attack (long period) approximations- solutions. Determination of longitudinal and lateral stability from coefficients of characteristic equation- stability and lateral stability from coefficients of characteristics equation- stability criteria, Aircraft spin- entry, balance of forces in steady spin, recovery, pilot techniques. Numerical.

V. TEXT BOOKS:

1. Nelson, R.C, "Flight Stability and Automatic Control", Tata McGraw Hill, 2nd Edition, 2007, ISBN 0-07-066110-3.
2. Yechout, T.R. etal., "Introduction to Aircraft Flight Mechanics", AIAA Education Series, 2003, ISBN 1-56347-577-4.
3. Etkin, B and Reid, L.D., "Dynamics of Flight", Pearson Press, John Wiley, 3rd Edition, 1998, ISBN0-47103418-5.

VI. REFERENCE BOOKS:

1. Schmidt, L.V., "Introduction to Aircraft Flight Dynamics", AIAA Education Series, 1st Edition, 1998, ISBN A-56347-226-0.
2. McCormick, B.W., "Aerodynamics, Aeronautics, and Flight Mechanics", Wiley India, 2nd Edition, 1995, ISBN 97.

VII. WEB REFERENCES:

1. www.scribd.com/book/282507871/Performance-and-Stability-of-Aircraft
2. www.nptel.ac.in/courses/101106043/
3. www.nptel.ac.in/courses/101106042/
4. www.scribd.com/document/174035182/Flight-mechanics

VIII. E-TEXT BOOKS:

1. www.csobeech.com/files/AirplanePerformanceStabilityandControl.pdf
2. www.books.google.co.in/books?isbn=1600860788