# AIRCRAFT STABILITY AND CONTROL

**V Semester: AE**

| Course Code | Category | Hours / Week | | | Credits | Maximum Marks | | |
|---|---|---|---|---|---|---|---|---|
| | | L | T | P | C | CIA | SEE | Total |
| AAEB13 | Core | 3 | - | - | 3 | 30 | 70 | 100 |
| Contact Classes: 45 | Tutorial Classes: Nil | Practical Classes: Nil | | | | Total Classes: 45 | | |

**OBJECTIVES:**

**The course should enable the students to:**

I. Illustrate concept of stability and application to dynamic systems like Aircraft, and the role of primary controls and secondary controls in longitudinal stability.
II. Understand the concept of slide slip angle, roll angle and yaw angle their concepts related to lateral-directional stability.
III. Learn about the mathematical modeling of an aircraft in longitudinal, lateral and directional cases.
IV. Estimate the longitudinal and directional parameters with the help of the linearzed equations of aircraft motion.
V. Analyze the different type of modes in longitudinal, lateral and directional motion of aircraft, and recovery from those modes.

| MODULE-I | INTRODUCTION AND LONGITUDINAL STABILITY-I | Classes: 10 |
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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. Equations of equilibrium- stick fixed neutral point, elevator angle required to trim. Definition-static margin. Equations of motion in steady, 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, forward and aft most limits of CG.

| MODULE-II | LATERAL-DIRECTIONAL STATIC STABILITY | Classes: 09 |
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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, directional static stability, Aircraft component contribution for lateral-directional stability, rudder requirements.

| MODULE-III | AIRCRAFT EQUATION OF MOTION | Classes: 10 |
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Description of motion of Flight vehicle - systems of reference frames - earth, body, wind, stability axes - relative merits. Euler angles, angles of attack and sideslip– 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.

| MODULE-IV | LINEARIZATION OF EQUATIONS OF MOTION AND AERODYNAMIC FORCES AND MOMENTS DERIVATIVES | Classes: 09 |
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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. Linearised of force and moment equation, of

motion, Linearised 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).

| **MODULE-V** | **AIRCRAFT DYNAMIC STABILITY** | **Classes: 07** |
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Principle modes of motion characteristics, mode shapes and significance, time constant, undamped 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.

**Text Books:**


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


**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", WileyIndia, 2nd Edition, 1995, ISBN 97.


**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

**E-Text Books:**

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