INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad - 500 043

AERONAUTICAL ENGINEERING

COURSE DESCRIPTOR

Course Title	**AIRCRAFT STABILITY AND CONTROL**				
Course Code	AAEB13				
Program	B.Tech				
Semester	FIVE				
Course Type	Core				
Regulation	IARE - R18				
Course Structure	**Theory**			**Practical**	
	Lectures	**Tutorials**	**Credits**	**Laboratory**	**Credits**
	3	1	3	-	-
Course Coordinator	Dr. Yagya Dutta Dwivedi, Professor				

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 PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AAEB11	IV	Aircraft Performance

III. MARKS DISTRIBUTION:

Subject	SEE Examination	CIA Examination	Total Marks
Aircraft Stability and Control	70 Marks	30 Marks	100

IV. DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✔	PPT	✔	Chalk & Talk	✔	Assignments	✗	MOOCs
✔	Open Ended Experiments	✔	Seminars	✗	Mini Project	✔	Videos
✔	Others						

V. EVALUATION METHODOLOGY:

The course will be evaluated for a total of 100 marks, with 30 marks for Continuous Internal Assessment (CIA) and 70 marks for Semester End Examination (SEE). Out of 30 marks allotted for CIA during the semester, marks are awarded by taking average of two CIA examinations or the marks scored in the make-up examination.

Semester End Examination (SEE): The SEE is conducted for 70 marks of 3 hours duration. The syllabus for the theory courses is divided into FIVE modules and each module carries equal weightage in terms of marks distribution. The question paper pattern is as follows. Two full questions with "either" or "choice" will be drawn from each module. Each question carries 14 marks. **There could be a maximum of two sub divisions in a question.**

The expected percentage of cognitive level of the questions is broadly based on the criteria given in Table: 1.

Table 1: The expected percentage of cognitive level of questions in SEE

Percentage of Cognitive Level	Blooms Taxonomy Level
10 %	Remember
50 %	Understand
25 %	Apply
15 %	Analyze
0 %	Evaluate
0 %	Create

Continuous Internal Assessment (CIA):

CIA is conducted for a total of 30 marks (Table 2), with 20 marks for Continuous Internal Examination (CIE), 05 marks for Quiz and 05 marks for Alternative Assessment Tool (Table 3).

Table 2: Assessment pattern for CIA

Component	Theory			Total Marks
Type of Assessment	CIE Exam	Quiz	AAT	
CIA Marks	20	05	05	30

Continuous Internal Examination (CIE):

Two CIE exams shall be conducted at the end of the 8th and 16th week of the semester respectively. The CIE exam is conducted for 20 marks of 2 hours duration consisting of five descriptive type questions out of which four questions have to be answered where, each question carries 5 marks. Marks are awarded by taking average of marks scored in two CIE exams

Quiz – Online Examination:

Two Quiz exams shall be online examination consisting of 25 multiple choice questions and are to be answered by choosing the correct answer from a given set of choices (commonly four). Such a question paper shall be useful in testing of knowledge, skills, application, analysis, evaluation and understanding of the students. Marks shall be awarded considering the average of two quiz examinations for every course.

Alternative Assessment Tool (AAT):

This AAT enables faculty to design own assessment patterns during the CIA. The AAT converts the classroom into an effective learning center. The AAT may include tutorial hours/classes, seminars, assignments, term paper, open ended experiments, METE (Modeling and Experimental Tools in Engineering), five minutes video, MOOCs etc. The AAT chosen for this course is given in table 3**.**

Table 3: Assessment pattern for AAT

5 Minutes Video	Assignment	Tech-talk	Seminar	Open Ended Experiment
20%	30%	30%	10%	10%

VI. COURSE OBJECTIVES (COs):

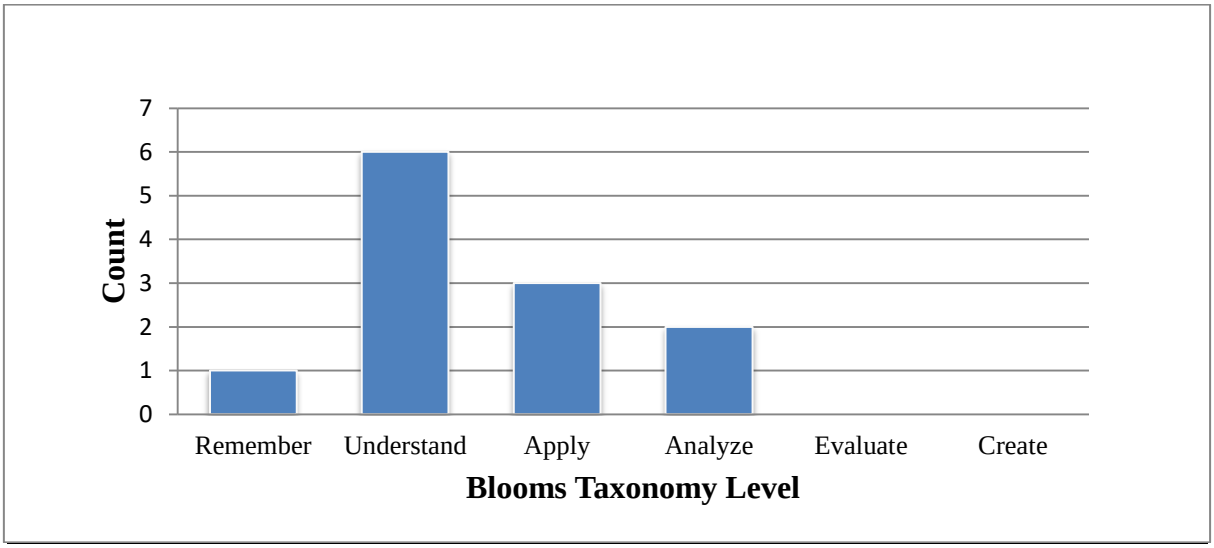
The students will try to learn:	
I	The fundamental knowledge on static stability of aircraft in multiple directional motions with their relationship for critical applications in flight vehicles.
II	The aircraft equations of motion to correlate qualitatively with potential applications in aircraft stability 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 and development of modern airplane control systems.

VII. COURSE OUTCOMES (COs):

After successful completion of the course, students will be able to:		
Course Outcomes		Knowledge Level (Bloom's Taxonomy)
CO 1	**Recall** the concept of static stability in longitudinal, lateral and directional modes to be used for different aircrafts stability conditions.	Remember
CO 2	**Describe** the state of an equilibrium, control and trim inputs required for an aircraft in static longitudinal and lateral directional stability.	Understand
CO 3	**Recognize** the aircraft components contributing to the stability of different aircraft models like Military, Civil and transport aircrafts.	Understand

CO 4	**Identify** stick fixed and stick free conditions for neutral points with an appropriate static margin, control force and CG limitation.	Apply
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.	Understand
CO 6	**Construct** the mathematical model of aircraft motion in longitudinal, lateral and directional cases for establishing the status of the flight vehicles stability.	Apply
CO 7	**Outline** the contribution of aircraft components and their influence on lateral and directional static stability on flight vehicles.	Understand
CO 8	**Analyze** different axis systems used for flight dynamics and their transformations from one system to another system.	Analyze
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.	Understand
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.	Understand
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.	Analyze
CO 12	**Apply** the advances of flight dynamics and controls in design of modern airplane control systems.	Apply

COURSE KNOWLEDGE COMPETENCY LEVELS



VIII. HOW PROGRAM OUTCOMES ARE ASSESSED:

Program Outcomes		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	CIE/Quiz/AAT

Program Outcomes		Strength	Proficiency Assessed by
PO 2	**Problem analysis**: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences	3	CIE/Quiz/AAT
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	2	Seminar/ Conferences/ Research Papers
PO 5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modelling to complex Engineering activities with an understanding of the limitations.	2	Assignments/ Discussion
PO 9	**Individual and Teamwork:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings	2	Class group/ Multi-disciplinary group
PO 10	**Communication:** Communicate effectively on complex Engineering activities with the Engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.	2	Discussion on Innovations/ Presentation
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.	1	Research paper analysis/ Short term courses

3 = High; 2 = Medium; 1 = Low

IX. HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program Specific Outcomes		Strength	Proficiency assessed by
PSO 2	Focus on broad knowledge of aeronautical engineering in innovative, dynamic challenging environment for design and development of new products.	1	Research papers/ Group discussion/ Short term courses
PSO 3	Make use of design, computational and experimental tools for research and innovation in aerospace technologies and allied streams, to become successful professional, entrepreneurs and desire higher studies.	2	Research papers / Industry exposure

3 = High; 2 = Medium; 1 = Low

X. MAPPING OF EACH CO WITH PO(s), PSO(s):

Course Outcomes	Program Outcomes												Program Specific Outcomes		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO 1	√	-	-	-	-	-	-	-	-	-	-	-	-	-	-

CO 2	√	-	-	-	√	-	-	-	-	√	-	-	-	-	-
CO 3	√	√	-	-	-	-	-	-	-	-	-	-	-	-	√
CO 4	√	√	-	-	-	-	-	-	√	-	-	-	-	-	-
CO 5	√	-	-	-	√	-	-	-	-	√	-	-	-	-	-
CO 6	√	√	-	√	-	-	-	-	√	-	-	-	-	-	√
CO 7	√	√	-	√	-	-	-	-	-	-	-	-	-	√	-
CO 8	√	√	-	-	√	-	-	-	-	-	-	-	-	-	-
CO 9	√	-	-	-	-	-	-	-	-	√	-	-	-	-	√
CO 10	√	-	-	-	√	-	-	-	√	-	-	-	-	-	√
CO 11	√	√	-	√	-	-	-	-	-	-	-	-	-	-	√
CO 12	√	-	-	-	-	-	-	-	-	-	-	√	-	√	-

XI. JUSTIFICATIONS FOR CO – (PO, PSO) MAPPING - DIRECT

Course Outcomes	POs / PSOs	Justification for mapping (Students will be able to)	No. of Key Competencies
CO 1	**PO 1**	Recollect (knowledge) the basic concept of static stability and to an extent appreciate (understand) the importance of longitudinal, lateral and directional modes of stabilityby applying the principles of **mathematics and science.**	3
CO 2	**PO 1**	Describe (knowledge) the state of equilibrium, control and trim inputs required (understanding) for an aircraft in static longitudinal and lateral directional stability **using principles of mathematics, science, and engineering fundamentals.**	2
	PO 5	Interpret (knowledge) about state of equilibrium, trim condition in longitudinal and lateral stability by using appropriate techniques with an **understanding** of the limitations of **Modern Tools**.	1
	PO 10	Comprehend and write effective reports on the state of equilibrium and the trim condition in longitudinal and lateral static stability by developing good **communication.**	4
CO 3	**PO 1**	Recognizing (knowledge) the contribution of aircraft components which affects static stability of airplane (application) by using **scientific principles and methodology.**	2
	PO 2	Recognize problems related to design of civil and military aircraft stability characteristics in longitudinal/ lateral direction by using **first principles of mathematics and engineering sciences.**	6
	PSO 3	**Make use of experimental tools for innovation** to assess aircraft behaviour in different stages of aircraft flight **to obtain desired knowledge for higher studies.**	1
CO 4	**PO 1**	Identify (knowledge)the stick fixed and stick free neutral point and effects on stability with the **fundamentals of mathematics, science, and engineering fundamentals.**	3

	PO 2	Apply (knowledge) the appropriate stability conditions for c.g location with respect to neutral point to reach substantiated conclusions (application) using **first principles of mathematics and engineering sciences.**	7
	PO 9	Focus on working as a member or leader in executing the design conditions about Centre of gravity and Neutral point in a model by **individual and team work**.	7
CO 5	**PO 1**	Interpret the specific coupling between lateral and directional static stability with the **knowledge of mathematics, science and engineering fundamentals related to aeronautics.**	2
	PO 5	Determine the influence of the coupling between longitudinal and lateral motions **using modern Engineering and IT tools to solve complex stability problem.**	1
	PO 10	Recognize the importance of coupling in longitudinal and lateral stability modes by **communicating effectively to with engineering community.**	4
CO 6	**PO 1**	Construct the mathematical model of of aircraft motion in longitudinal direction by **Knowledge and understanding** of complex engineering problem using **mathematical principles.**	2
	PO 2	Derive the mathematical model of aircraft motion in lateral and directional cases for establishing the stability of the flight vehicles **using first principles of science and mathematics.**	7
	PO 4	Understanding the engineering principles for characteristics of stability features of aircraft in different axes system by **conducting investigations of the given problem in different conditions.**	8
	PO 9	Demonstrate the ability of the individual or in a team to apply the aircraft motion to make a prototype **in diverse or multidisciplinary settings.**	8
	PSO 3	Understand the characteristics of aircraft longitudinal / lateral stability by using modern tool to go further one level to **become entrepreneur**.	2
CO 7	**PO 1**	Outline the contribution of aircraft components on static stability by using **basic fundamentals of mathematics, science and engineering.**	3
	PO 2	Determine standard expressions of effects of components on static stability for **analysing behaviour of complex aeronautical system.**	7
	PO4	Understand the use of technical literature and other information related to the effects of components on stability by conducting **synthesis of the information.**	7
	PSO 2	Extend the focus to understand the **innovative and dynamic challenges involve** designing the RC airplane for specific role.	1
CO 8	**PO 1**	Analyze (examine and break information) different axis systems used for flight dynamics of an airplane using**fundamentals of mathematics, science, and engineering fundamentals.**	2
	PO 2	Examine transformations of axes from one system to another systemby application of **basics of mathematics and engineering sciences.**	6
	PO 5	Make use of computational/ Experimental tools t**o synthesize and analyse** stability and control phenomena of the airplane by application of **Modern tools.**	1

CO 9	**PO 1**	Explain qualitatively about motion of aircraft in three-dimensions **using the principles of mathematics and engineering fundamentals.**	3
	PO 10	Illustrate the Euler angles and rates in 6-DOF equations for rigid symmetrical aircraft **using complex engineering problems can be solved with help of basic mathematics and engineering sciences.**	5
	PSO 3	Extend the concept of equations of motion in airplane to solve complex aeronautical problems using modern engineering tools to become a **successful professional in the domain**.	2
CO 10	**PO 1**	Demonstrate different stability derivatives used for solving stability and control problems in aircraftsby **applying basic knowledge of science and engineering fundamentals.**	3
	PO 5	Illustrate different stability derivatives used for assessing dynamic stability in aircrafts using modern **design solutions for complex engineering problems.**	1
	PO 9	Show the ability to work with different individual and as a group to solve static and dynamic stability problems in a **diverse and multidisciplinary setting.**	6
	PSO 3	Acquire sufficient knowledge in field of stability and control by using modern computational and experimental tools so that new innovation can take place, which leads to become **successful entrepreneur and or to obtain higher education.**	1
CO 11	**PO 1**	Analyze different types of dynamic modes of the aircraft and the effects of the modes on dynamic stability **using knowledge of mathematics, science and engineering fundamentals.**	3
	PO 2	Compare different dynamic modes in longitudinal, lateral and directional motion of the aircraft and their influence on dynamic stability and safety **by analyzing complex engineering problems reaching substantiated conclusions using first principles of mathematics and engineering sciences.**	7
	PO 4	Understand the use of literature survey and other information related to the effects of components on dynamic stability by conducting **synthesis of the information.**	6
	PSO 3	Acquire sufficient knowledge in dynamic modes by using modern computational and experimental tools so that new product can be developed, which leads to become **successful entrepreneur in the present market.**	2
CO 12	**PO 1**	Build strong foundation of flight dynamics and controls in design of modern airplane control systems **using knowledge of mathematics, science and engineering fundamentals.**	3
	PO 12	Recognize the need and have sufficient preparation in field of aircraft stability and control (Flight dynamics) to enhance skill and additional efforts for **future advancement and life long learning**.	9
	PSO 2	Make use of broad knowledge of stability and control in innovative, dynamic challenging environment for **design and development of new products.**	1

XII. TOTAL COUNT OF KEY COMPETENCIES FOR CO – (PO, PSO) MAPPING

Course Outcomes	Program Outcomes / No. of Key Competencies Matched												PSOs/ Number of key competencies		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
	3	10	10	11	1	5	3	3	12	5	12	12	2	2	2
CO 1	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 2	2	-	-	-	1	-	-	-	-	4	-	-	-	-	-
CO 3	2	6	-	-	-	-	-	-	-	-	-	-	-	-	1
CO 4	3	7	-	-	-	-	-	-	7	-	-	-	-	-	-
CO 5	2	-	-	-	1	-	-	-	-	4	-	-	-	-	-
CO 6	2	7	-	8	-	-	-	-	8	-	-	-	-	-	2
CO 7	3	7	-	7	-	-	-	-	-	-	-	-	-	2	-
CO 8	2	6	-	-	1	-	-	-	-	-	-	-	-	-	-
CO 9	3	-	-	-	1	-	-	-	-	3	-	-	-		2
CO 10	3	-	-	-	1	-	-	-	6	-	-	-	-	-	1
CO 11	3	7	-	6	-	-	-	-	-	-	-	-	-	-	2
CO 12	3	-	-	-	-	-	-	-	-	-	-	9	-	1	-

XIII. PERCENTAGE OF KEY COMPETENCIES FOR CO – (PO, PSO):

Course Outcomes	Program Outcomes / No. of key competencies												PSOs / No. of key competencies		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
	3	10	10	11	1	5	3	3	12	5	12	12	2	1	2
CO 1	100.0	70.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CO 2	66.7	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	80.0	0.0	0.0	0.0	0.0	0.0
CO 3	66.7	60.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	50.0
CO 4	100.0	70.0	0.0	0.0	0.0	0.0	0.0	0.0	58.3	0.0	0.0	0.0	0.0	0.0	0.0
CO 5	66.7	70.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	80.0	0.0	0.0	0.0	0.0	0.0
CO 6	66.7	70.0	0.0	80.0	0.0	0.0	0.0	0.0	67.0	0.0	0.0	0.0	0.0	0.0	100.0
CO 7	100.0	70.0	0.0	70.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0

CO 8	66.7	60.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CO 9	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	60.0	0.0	0.0	0.0	0.0	100.0
CO 10	100.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	50.0	0.0	0.0	0.0	0.0	0.0	50.0
CO 11	100.0	70.0	0.0	60.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0
CO 12	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	75.0	0.0	100.0	0.0

XIV. COURSE ARTICULATION MATRIX (PO – PSO MAPPING)

COs and POs and COs and PSOs on the scale of 0 to 3, **0** being **no correlation**, **1** being the **low correlation**, **2** being **medium correlation** and **3** being **high correlation**.

0 – **0**≤ ***C***≤ 5% – Nocorrelation
1 – 5 <***C***≤ 40% – Low/ Slight
2 − 40 % <***C***< 60% –Moderate
3 – 60% ≤ ***C***< 100% – Substantial /High

Course Outcomes	**Program Outcomes**												**Program Specific Outcomes**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO 1	3	3	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 2	2	-	-	-	3	-	-	-	-	3	-	-	-	-	-
CO 3	2	-	-	-	-	-	-	-	-	-	-	-	-	-	2
CO 4	3	3	-	-	-	-	-	-	3	-	-	-	-	-	-
CO 5	2	3	-	-	3	-	-	-	-	3	-	-	-	-	-
CO 6	2	3	-	3	-	-	-	-	3	-	-	-	-	-	3
CO 7	3	3	-	3	3	-	-	-	-	-	-	-	-	-	-
CO 8	2	3	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 9	3	-	-	-	3	-	-	-	-	3	-	-	-	3	3
CO 10	3	-	-	-	-	-	-	-	2	-	-	-	-	-	2
CO 11	3	-	-	3	-	-	-	-	-	-	-	-	-	-	3
CO 12	3	-	-	-	-	-	-	-	-	-	-	3	-	3	-
TOTAL	31	18		9	12				8	9		3		6	13
AVERAGE	**2.6**	**3.0**		**3.0**	**3.0**				**2.7**	**3.0**		**3.0**		**3.0**	**2.6**

XV. ASSESSMENT METHODOLOGY - DIRECT

CIE Exams	PO1,PO2	SEE Exams	PO1,PO2, PO4	Assignments	PO1,PO2, PO5	Seminars	PO 9, PO10, PO12

Laboratory Practices	-	Student Viva	-	Mini Project	-	Certification	-
Term Paper	PO4	5 Minutes Video	PO5	Tech talk	PO10	Open Ended Experiments	PO12

XVI. ASSESSMENT METHODOLOGY - INDIRECT

✔	Early Semester Feedback	✔	End Semester OBE Feedback
✗	Assessment of Mini Projects by Experts		

XVII. SYLLABUS

Module-I	**INTRODUCTION AND LONGITUDINAL STABILITY-I**
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**
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 on directional static stability, Aircraft component contribution for lateral-directional stability, rudder requirements.	
Module-III	**AIRCRAFT EQUATION OF MOTION**
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. 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**
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.	
Module-V	**AIRCRAFT DYNAMIC STABILITY**
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.
Textbooks:
1. Yechout, T.R.et al., "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.G. 2. McCormick, B.W., "Aerodynamics, Aeronautics, and Flight Mechanics", Wiley India, 2nd Edition, 1995, ISBN 97.

XVIII. COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

Lecture No	Topics to be Covered	COs	Reference
1-2	Describe the basic aerodynamics**,** atmosphere, characteristics of airfoils, forces and moments, aircraft axis system, equilibrium.	CO 1	T2:1.1-1.5 T1: 4.1
3-4	Recall the stability, controllability and maneuverability. Practical example of stability, longitudinal static stability and dynamic static stability.	CO 1	T2: 2.1-2.2 R1:3.1
5-6	Identify the accelerated flight, Criteria for longitudinal static stability and trim condition. Contribution of the components of static stability, Equations of equilibrium.	CO 2	T2: 2.3-2.4
7-8	Recall the Stick fixed neutral point, Elevator angle required to trim, Static margin, Equation of motion in steady pull maneuver.	CO 2	T2: 2.5-2.6, R1:3.3
9-10	Recognize the elevator effectiveness and elevator hinge moment.	CO 3	T2: 3.3
11	Explain about control force and control gradient, neutral point, maneuver point.	CO 4	T2:3.4, R1: 4.1
12	Explain about **t**rim tabs and types of trim tabs, static margin for stick fixed and stick free conditions.	CO 5	T2: 3.4
13-14	Apply aerodynamic and mass balancing of control surfaces, forward and aft most limits of CG.	CO 5	T2: 3.3
15-16	Recognize. Introduction to lateral-direction stability-aerodynamic forces and moments.	CO 6	T2: 4.2
17-18	Explain about the aircraft side force due to side slip, aircraft rolling moment due to side slip.	CO 6	T2: 5.1
19-20	Define about the aircraft yawing moment due to side slip, aircraft component contribution, directional static stability.	CO 7	T2: 5.2
21-22	Estimate the aircraft component contribution for lateral-directional stability, rudder requirements.	CO 7	T2: 5.3
23-24	Recognize description of motion of Flight vehicle - systems of reference frames - Earth, body, wind.	CO 8	T2: 4.5
25	Recall Stability axes - relative merits. Euler angles, angles of attack and sideslip.	LO 8	T1: 4.1
26	Define- Earth to body axis transformation, stability axis to body axis transformation.	CO 9	T1: 4.2

Lecture No	Topics to be Covered	COs	Reference
27-28	Recognize rotating axis system- expressions for linear and angular moment of rigid body, time derivatives-inertia tensor.	CO 9	T1: 4.3
29-30	Recall Components of linear and angular velocities, accelerations. Components of aerodynamic, gravity forces, moments applied on flight vehicle.	CO 10	T2: 5.2
31-32	Interpret Equations of motion- longitudinal and lateral-directional. Relation between angular velocity components and Euler angle rates. Determination of velocities of airplane in earth axis system.	CO 10	T2: 5.2
33-34	Interpret description of state of motion of vehicle, forces and moments as perturbations over prescribed reference flight condition.	CO 11	T2: 5.3
35-36	Explain Equation of motion in perturbation variables, Assumption of small perturbations, first order approximations-linearization equations of motion.	CO 11	T1: 6.1-6.2
37-38	Identify linearized of force and moment equation of motion Linearized longitudinal and lateral-directional equations of perturbed motion. Significance of aerodynamic derivatives.	CO 11	T1: 6.3, R2:6.1
39-40	Inferderivatives of axial, normal force components and pitching moment with respect to the velocity, angle of attack, angle of attack rate, pitch rate, elevator angle.	CO 11	T1: 6.4
41-42	Identify Principle modes of motion characteristics, mode shapes and significance, time constants.	CO 11	T1: 6.5
43-44	Interpret undamped natural frequency and damping ratio, mode shapes, significance.	CO 11	T1: 7.1
45-46	Recall One degree of freedom, two degree of freedom approximations- constant speed (short period).	CO 11	T1: 7.2
47	State and apply Constant angle of attack (long period) approximations-solutions.	CLO 11	T1: 7.3
48-49	Calculate longitudinal and lateral stability from coefficients of characteristic equation.	CO 12	T1: 7.4, R2:4.1-4.4
50-51	Explain Stability and lateral stability from coefficients of characteristics equation-stability criteria.	CO 12	T1: 7.5, R2:7.3
52-53	Apply the concept of aircraft spin- entry, balance of forces in steady spin.	CO 12	T1: 7.6
54-55	Apply the concept of recovery methods, pilot techniques for recovery.	CO 12	T1: 7.7

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