FLIGHT CONTROL THEORY

VII Semester: AE								
Course Code	**Category**	**Hours / Week**			**Credits**	**Maximum Marks**		
AAE018	**Core**	**L**	**T**	**P**	**C**	**CIA**	**SEE**	**Total**
		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. Apply stability criteria to determine the stability of an aircraft, and specify the aircraft time-domain and frequency-domain response specifications.
II. Understand classical control theory in the frequency domain and modern control theory in the state-space are effectively mixed to provide the student with a modern view of systems theory.
III. Design control techniques for aircraft control systems, and study some feedback control applications.
IV. Study the controllability and observability of aerospace systems, and apply the modern control techniques to design enhanced flight control systems.

COURSE OUTCOMES:

The course should enable the students to:

I. Describe the analysis techniques for classical control theory to nonlinear system
II. To describe and analyze the physical system with inherent non-linearity for stability and performance
III. Provide knowledge on various adaptive schemes, with a basic understanding on closed loop system stability and implementation issues
IV. Describe the principle of approximations to aircraft transfer functions, control surface actuators-review. response of aircraft to elevator input, response of aircraft to rudder input and response of aircraft to aileron input to atmosphere
V. Define reversible and irreversible flight control systems. flying qualities of aircraft-relation to airframe transfer function. pilot's opinion ratings. flying quality requirements- pole-zero, frequency response and time- response specifications

COURSE LEARNING OUTCOMES (CLOs):

1. Define the basic concepts associated with control Theory and its application.
2. Review Fourier transform with mathematical operations and its applications.
3. Review Laplace transform and some other important mathematical operations.
4. Understand about the concepts of transfer function, its merits and applications.
5. Understand the control system performance with the time domain description.
6. Analyze the steady state response and application of feedback in augmentation controls.
7. Understand the control system performance with the frequency domain description.
8. Analyze an aircraft's performance to controls and related aspects.
9. Evaluate an aircraft's performance from the control point of view as a system.
10. Determine the approximations to aircraft transfer functions.
11. Understand about stability augmentation systems for an aircraft with autopilot system.
12. Determine the flying qualities of aircraft and requirements.
13. Understand about the concepts of feedback control its merits and applications.
14. Understand the concept of control surface actuators and its usage in aircraft applications.
15. Determine the displacement and feedback determination of conflict with pilot inputs resolution.

UNIT-I	INTRODUCTION TO CONTROL SYSTEMS	Classes: 10
Dynamical systems-principal constituents-input, output-process (plant)-block diagram representation. Inputs- control input, noise. Function of controls regulation (hold), tracking (command)-examples. Measure of effectiveness. Sensitivity of output to control input, noise and system parameters-robustness. Deterministic and stochastic control. Control in everyday life. The pervasiveness of control in nature, engineering and societal systems. The importance of study of control system. Need for stable, effective (responsive), robust control system. Modeling of dynamical systems by differential equations-system parameters. Examples from diverse fields. First and second order systems, higher order systems, single input single output systems, and multiple-input multiple-output.		
UNIT-II	**MATHEMATICAL MODELLING OF DYNAMIC SYSTEMS**	**Classes: 10**
Control system performance- time domain description- output response to control inputs-- impulse and indicial response- characteristic parameters- significance- relation to system parameters- examples- first and second order linear systems, higher order systems. Synthesis of response to arbitrary input functions from impulse and indicial response. Review of Fourier transforms and Laplace transforms- inverse transforms- significance, applications to differential equations. 's' (Laplace) domain description of input-output relations- transfer function representation- system parameters- gain, poles and zeroes. Characteristic equation- significance- examples. Frequency and damping ratio of dominant poles. Relation of transfer functions to impulse response. Partial fraction decomposition of transfer functions-significance.		
UNIT-III	**STEADY STATE RESPONSE ANALYSIS**	**Classes: 10**
System type, steady state error, error constants- overall system stability. Application of feedback in stability augmentation, control augmentation, automatic control-examples. Composition, reduction of block diagrams of complex systems-rules and conventions. Control system components - sensors, transducers, servomotors, actuators, filters-modeling, transfer functions. Single-input single-output systems. Multiple input-multiple output systems, matrix transfer functions-examples. Types of control problems- the problem of analysis, control synthesis, system synthesis- examples- static control of aircraft. Extension to dynamic control. System identification from input output measurements importance. Experimental determination of system transfer functions by frequency response measurements. Example. Frequency domain description- frequency response- gain and phase shift- significance- representation asymptotic (Bode) plots, polar (Nyquist) plots, frequency transfer functions. Characteristic parameters corner frequencies, resonant frequencies, peak gain, and bandwidth- significance. First and second order systems- extension to higher order systems.		
UNIT -IV	**AIRCRAFT RESPONSE TO CONTROLS**	**Classes:07**
Approximations to aircraft transfer functions, control surface actuators-review. Response of aircraft to elevator input, Response of aircraft to rudder input and Response of aircraft to aileron input to atmosphere. Need for automatic control. Auto pilots Stability augmentation systems-pitch damper and yaw damper.		
UNIT -V	**FLYING QUALITIES OF AIRCRAFT**	**Classes: 08**
Reversible and irreversible flight control systems. Flying qualities of aircraft-relation to airframe transfer function. Pilot's opinion ratings. Flying quality requirements- pole-zero, frequency response and time-response specifications. Displacement and rate feedback determination of gains conflict with pilot input s resolution-control augmentation systems- Full authority fly-by-wire. Auto Pilot-Normal acceleration, Turn rate, Pitch rate Commands-Applications.		

Text Books:

1. Kuo, B.C., —Automatic Control Systems, Prentice Hall India, 1992.
2. Stevens, B.L. and Lewis, F.L., —Aircraft Control and Simulation, John Wiley, 1992.

Reference Books:

1. Mc Lean, D., —Automatic Flight Control Systems, Prentice Hall, 1990 J.
2. Bryson, A.E., —Control of Aircraft and Spacecraft, Princeton University Press, 1994.
3. E H J Pallett, Shawn Coyle —Automatic Flight Control, 4th Edition, 2002.

Web References:

1. https://soaneemrana.org/onewebmedia/INTRODUCTION%20TO%20SPACE%20DYNAMICS/
2. https://nptel.ac.in/courses/101105030/

E-Text Books:

1. https://store.doverpublications.com/0486651134.html
2. https://www.worldcat.org/title/introduction-to-space-dynamics/oclc/867680515