AE 710
HELICOPTER DYNAMICS, STABILITY AND CONTROL (3-0) 3

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Course Description:

This course will introduce fundamentals of helicopter flight dynamics including aspects of modeling, simulation, stability and control of helicopters. Students will be introduced to general equations of motion of a helicopter, simplified trim equations, stability and control derivatives, static and dynamic stability of helicopters. Particular emphasize will be put on the analysis of the main rotor dynamics and the generation of main rotor forces and moments. Rotor flapping dynamics and dynamic inflow concepts will be introduced. Sufficient tools will be provided to analyze handling quality aspects of helicopters and the design of flight control systems for helicopters. Homework problems will involve the case-studies of specific helicopters and will familiarize students with real-life engineering problems.

At the end of this course you should have a fundamental understanding of the dynamics of rotary wing aircraft and should be able to write basic simulation models and analyze its dynamic behavior and provide flight controller solutions for desired handling quality performance.

Introduction:

An aircraft with a rotor as its lifting device has very unique dynamic characteristics and requires special attention for analysis. Tools introduced, through courses concentrating on non-rotary wing systems (conventional fixed wing aircraft, satellites, rockets, etc.) are not sufficient to understand the complex dynamics of a rotorcraft. However rotary wing aircraft -in particular helicopters- are the subject of major research in aerospace engineering. Special consideration is needed to provide the necessary tools to understand the dynamics of a rotor system or a full-size helicopter. The analysis will provide a unique inside on the general understanding of the dynamics of rotors and rotary wing aircraft; in particular helicopters. Although the course will focus on a classic helicopter configuration, it will provide the necessary tools to analyze any rotorcraft system, including advanced configurations like a tilt- rotor, auto-gyro, etc. Therefore the course will cover a special area in aerospace engineering addressing specialized issues related to rotary wing aircraft and should be of interest to any aerospace engineering student.

Course References:

1. Helicopter Theory, W. Johnson, Dover Publications, 1994.
2. Helicopter Flight Dynamics: The Theory and Application of Flying Qualities and Simulation Modeling, G.D. Padfield, AIAA Education Series, 1996.
3. Principles of Helicopter Aerodynamics, G. Leishman, Cambridge University Press, 2002
4. Helicopter Performance. Stability and Control, R. W. Prouty, Krieger Pub. Co., 2002.
5. Basic Helicopter Aerodynamics, J.Seddon, BSP Professional Books,1991

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Syllabus:

1. Introduction, basic terminology
2. General Equations of Motion
3. Rotor dynamics
4. Rotor wake and inflow dynamics
5. Rotor forces and moments
6. Simplified trim equations
7. Linearized equations of motion
8. Stability and control derivatives
9. Static stability characteristics
10. Longitudinal dynamics characteristics
11. Lateral/yaw dynamics characteristics
12. Handling qualities
13. Flight control system design

Grading:

Midterms	40%
Project/HW	20%
Final	40%

Pre-requisites:

This course does not have a pre-requisite, however a course in System Dynamics, such as AEE 383 is strongly recommended, AEE 501 Advanced Mathematics for Engineers and AE 372 Flight Mechanics are recommended prior to taking this course, but they are not mandatory. AEE 446 Introduction to Helicopter Aerodynamics and Helicopter Design is a fundamental class in the introduction of helicopters and specifically the understanding of rotary wing aerodynamics. Therefore, it is strongly recommended that this class is taken previously or is being taken in parallel. AE 710 will complement the course AEE 446 and would serve as a perfect extension and an advanced class in rotary wing analysis in graduate level.