UUM 534
Aircraft Flight Control Systems
Fall 2017-2018

Asst. Prof. N. Kemal Ure
Faculty of Aeronautics and Astronautics
Aerospace Research Center
Istanbul Technical University

Lecture Times and Office Hours

Time: Thursdays 08:30-11:30,
Place: Faculty of Aeronautics and Astronautics, D-108
Prof. Ure Office Hours: Wednesdays 14:30-15:30, Contact: ure@itu.edu.tr
Teaching Assistants: Burak Yuksek (burakyuksek@gmail.com) and Mehmet Ugur Akcal (m.ugur.akcal@gmail.com)

Course Objectives

- To provide students with a solid understanding of nonlinear aircraft dynamics and flight control systems.
- To present applications of classical and modern control theory to design of aircraft control systems.
- To provide students with simulation and analysis tools for performing graduate level research in aircraft control.

Prerequisites

- Basic knowledge of dynamical systems and classical control theory.
- Basic knowledge of flight mechanics and flight stability.
- Exposition to scientific programming.

Lecture Topics

- **Lecture 0:** Class Logistics
- **Lecture 1:** Brief History of Flight Control and Overview of GNC Systems
- **Lecture 2:** Review of Rigid Body Dynamics
  - Vector and Matrix Operations
  - Rotational Kinematics
  - Translational Kinematics
  - Geodesy, Coordinate Systems, Gravity
  - Rigid Body Dynamics

- **Tutorial** Modeling and Simulation using MATLAB/SIMULINK
- **Lecture 3:** Modeling the Aircraft
  - Basic Aerodynamics
  - Propulsion Models
  - Actuator Models
  - Nonlinear Aircraft Model
- **Lecture 4:** Design and Simulation Tools
  - State Space Models
  - Numerical Solution of Equations of Motion
  - Computation of Trim Inputs
  - Numerical Linearization
  - Analysis of Aircraft Dynamic Behavior
- **Lecture 5:** Classical Controller Design Methods
  - Handling Qualities
  - Stability Augmentation Systems
  - Control Augmentation Systems
  - Verification with Nonlinear Simulations
- **Lecture 6:** Modern Controller Design Methods
  - Assignment of Closed Loop Dynamics
  - Linear Quadratic Controller Design with Full State Feedback
  - Linear Quadratic Controller Design with Output Feedback
  - Model Following Design
- **Lecture 7:** Robustness Analysis and State Observer Design
  - Multivariable Frequency-Domain Analysis
  - Observers and Kalman Filter
  - Linear Quadratic Gaussian Controller Design
- **Lecture 8:** Navigation Filter Design
  - Fundamentals of Inertial Navigation
  - Navigation Error Equations
  - Sensor Error Models
  - GPS Fusion using Kalman Filter
- **Lecture 9:** Guidance Algorithm Design
  - Kinematic Guidance Models
  - Straight-Line Path Following
  - Orbit Following
  - Collision Free Path Planning
  - Path Smoothing

Textbooks

- Main Textbook: *Stevens, B. L., Frank, L. L., and Johnson, E. N., Aircraft Control and Simulation: Dynamics, Controls Design, and Autonomous Systems, 3rd Edition, John Wiley & Sons, 2015.*
- Secondary Textbook *Beard, R. W., and McLain, T. W., Small Unmanned Aircraft: Theory and Practice. Princeton University Press, 2012.*

Class Project

Grading will be completely based on the class project, which involves developing a software with following capabilities:

- Simulating 6 degrees of freedom nonlinear aircraft dynamics.
- Computing trim inputs for a given flight condition.
- Computing linearized equations of motion for a given trim point.
- Design and verification of various autopilots (such as stability augmentation systems, attitude hold etc.) using classical methods (such as root locus and Bode diagrams).

- Design and verification of various autopilots using modern methods (pole placement, LQR etc.)
- Design and verification of state observers and output feedback controllers (Kalman Filter, LQG etc.).
- Implementation of basic navigation filters (GPS-INS integration).
- Implementation of basic guidance modules (path following, obstacle avoidance etc.).

Grading Policies

- The project will be evaluated based on weekly progress reports and a final report.
- Progress reports will make up 60% of the final grade and the final report will make up 40% of the final grade.
- The project will be a team effort consisting of 3 students per team.
- Each team will pick an aircraft from a list presented by the instructor. Required numerical data (aerodynamic coefficients, aircraft geometry etc.) will be provided for each aircraft.
- Cheating is strictly monitored and the penalty is -100 (minus hundred) points per assignment.
- Late assignments get -30 (minus thirty) points for each day after the deadline.
- Reports typeset with LaTeXget $+10$ bonus points.

Classroom Policies

- No attendance is required.
- Coming late to the class is tolerated.
- Bringing computers to the class is welcome.
- Unregistered listeners are welcome.
- Interacting with the the instructor is strongly recommended.
- 2 hours(8:30-10:30) per class will be taught by the instructor. The remaining 1 hour (10:30-11:30) will consist of an interactive session with TAs where you can get feedback on your project's progress.