AE6400 ATMOSPHERIC FLIGHT DYNAMICS & CONTROL

Class Hours & Location: Monday 7:00PM - 9:20PM @ Parkview Campus Room C0122

Instructor & Office Hours: Dr. Kapseong Ro (Email: kapseong.ro@wmich.edu) (Tel: 276 – 3412) CEAS Parkview G224, MW 10:30AM - 11:30AM & by Appointment

Dynamics of Atmospheric Flight, Etkin, Wiely, 1972

Grading: Homework 40%
Midterm Project & Presentation 30%
Final Project & Presentation 30%

Course Objectives
- To develop broad understanding of the dynamics and control of atmospheric flight vehicles
- To develop skills on using commercial control system design software (MATLAB) for simulation and control system design of atmospheric flight vehicle

Tentative Topics to be covered:
1. Review of Rigid-body Dynamics
2. Development of General Nonlinear 6 DOF Aircraft Equations of Motion
3. Nonlinear Simulation
4. Aircraft Linear Model: Numerical vs. Literal
5. Linear Analysis for Aircraft Longitudinal & Lateral/Directional Stability and Control
6. Basics of Classical/Modern Feedback Control Design Techniques

Pre-requisites & Computer Skills: AE5400 & ME3600 and/or Consent of Instructor, MATLAB/Simulink

Academic Integrity Issue:
“You are responsible for making yourself aware of and understanding the policies and procedures in the Undergraduate and Graduate Catalogs that pertain to Academic Honesty. These policies include cheating, fabrication, falsification and forgery, multiple submission, plagiarism, complicity and computer misuse. [The policies can be found at http://catalog.wmich.edu under Academic Policies, Student Rights and Responsibilities.] If there is reason to believe you have been involved in academic dishonesty, you will be referred to the Office of Student Conduct. You will be given the opportunity to review the charge(s). If you believe you are not responsible, you will have the opportunity for a hearing. You should consult with your instructor if you are uncertain about an issue of academic honesty prior to the submission of an assignment or test.”

Dept. of Mechanical & Aerospace Engineering
Western Michigan University
# AE6400 Atmospheric Flight Dynamics & Control: Tentative Schedule

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<th>Week</th>
<th>Lecture Topics</th>
<th>Readings</th>
<th>Homework</th>
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<td>WK 01 9/5</td>
<td><strong>Labor Day: No Class</strong></td>
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| WK 02 9/12 | **Lecture 1. The Kinematics & Dynamics of Aircraft Motion**  
- Vectors, Reference Frame & Coordinate System  
- Rigid-body Kinematics  
- Rigid-body Dynamics | SLJ Ch.1 (1.1 ~ 1.8)  
AE5400 Notes | HW#1 |
| WK 03 9/19 | **Lecture 2. Modeling the Aircraft (I)**  
- Basic Aerodynamics  
- Aircraft Forces & Moments  
- Aerodynamic Tools for Aircraft Configuration Aerodynamics | SLJ Ch.2 (2.1~2.3) | HW#1 Due HW#2 |
| WK 04 9/26 | **Lecture 3. Modeling the Aircraft (II)**  
- Quick Review of Longitudinal Static Stability  
- The Nonlinear Aircraft Model  
- Linear Models & The Stability Derivatives | SLJ Ch.2 (2.4~2.7) | HW#2 Due HW#3 |
| WK 05 10/3 | **Lecture 4. Modeling, Design & Simulation Tools (I)**  
- State-Space vs. Transfer Function Model  
- Numerical Solution of the State Equations  
- Aircraft Models for Simulation | SLJ Ch.3 (3.1~3.5) | HW#3 Due HW#4 |
| WK 06 10/10 | **Lecture 5. Modeling, Design & Simulation Tools (II)**  
- Steady-state Flight & Linerization  
- Linear Aircraft Model: Numerical vs. Literal  
- Aircraft Dynamic Behavior | SLJ Ch.3 (3.6~3.8) | HW#4 Due Midterm Project |
| WK 07 10/17 | **Lecture 6. Aircraft Dynamics & Classical Control Design (I)**  
- Aircraft Rigid-body Modes  
- The Handling-Qualities Requirements  
- Review of Feedback Control & Classical Design Technique | SLJ Ch.4 (4.1~4.3)  
SLJ Ch.3 (3.9) | HW#5 |
| WK 08 10/24 | **In-class Presentation of Midterm Project Result** | | Midterm Project Report Due |
| WK 09 10/31 | **Lecture 7. Aircraft Dynamics & Classical Control Design (II)**  
- Stability & Control Augmentation Systems (S/CAS)  
- Autopilots  
- Nonlinear Simulation | SLJ Ch.4 (4.4~4.8) | HW#5 Due HW#6 |
| WK 10 11/7 | **Lecture 8. Modern Design Technique (I)**  
- State-Space Analysis: Stability, Controllability & Observability  
- State-Space Design: State feedback vs. Output feedback  
- Assignment of Closed-loop Dynamics | SLJ Ch.5 (5.1~5.9)  
Notes | HW#6 Due HW#7 |
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<th>WK</th>
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| 11  | 11/14 | Lecture 9. Modern Design Technique (II) | • Pole Placement & Eigen-Structure Assignment  
• Full State Feedback and Observer  
• A Short Introduction to Optimal Control |                  |          |
| 12  | 11/21 | Lecture 10. Modern Design Technique (III) | • Linear Quadratic Regulator (LQR) Fundamentals  
• Linear Quadratic Output Feedback  
• Full State Feedback Linear Quadratic Design |                  |          |
| 13  | 11/28 | Lecture 11. Modern Design Technique (IV) | • Modifying Performance Index  
• Model-Following Design  
• Preview of Robust Control Design |                  |          |
| 14  | 12/05 | Lecture 12. Gain Scheduling & Preview of Advanced Topics | • Gain Scheduling  
• Linear Quadratic Gaussian (LQG) Controller  
• Preview of Robust Control Design |                  |          |
| Final | 12/12 | 12/12 Monday: In-class Presentation of Final Project Result |                           |                  | Final Project |