ENG ME 403 Atmospheric Flight Mechanics and Control

2008 - 2009 Catalog Data:
ENG ME 403 Atmospheric Flight Mechanics and Control Prereq: ENG ME 302, ENG ME 400, and ENG ME 421. Introduction to stability and control of atmospheric flight vehicles. Forces and moments on aircraft. Static and dynamic stability. Equations of motion. Feedback design using root locus. Flying quality standards. Longitudinal and lateral autopilots. Cannot be taken for credit in addition to ME 404, ENG BE 402, or ENG EC 402. Includes design project and lab. 4 cr.

Class/Lab Schedule: 4 lecture hours per week

Status in Curriculum: Required for Aerospace Program

Textbook(s) and/or Other Required Material: Bernard Etkin and Lloyd Duff Reid, "Dynamics of Flight: Stability and Control", 3rd edition, Wiley & Sons, 1996
John Van de Vegte, "Feedback Control Systems", 3rd edition, Prentice Hall, 1994

Coordinator: Hua Wang, Associate Professor, Mechanical Engineering

Prerequisites by Topic:
1. Rigid body mechanics
2. Solutions of linear ordinary differential equations
3. Basic aerodynamics

Goals:
This course exposes seniors in Aerospace Engineering to fundamental concepts in the stability and control of atmospheric flight vehicles.

Course Learning Outcomes:
As an outcome of completing this course, students will:

i. Become proficient in the modeling and analysis of static stability and control aircraft - The cornerstone of this portion of the class in the analyses of static aerodynamic forces and moments on aircraft components such as wings, body, nacelle, tail, and propulsion. Also included is the linearization of aerodynamic forces and moments about an equilibrium condition. Students learn static control via elevators and tabs. (A, E, L, N)
ii. Become proficient in the modeling and analysis of aircraft dynamics - This knowledge begins with the fully nonlinear rigid-body equilibrium of motion for the aircraft. The relationship between aerodynamic forces and moments to aircraft motion via aerodynamic derivatives are learned. Students also learn to linearize these equations, place them in state space form and compute the transient response as a sum of solutions to the matrix eigenvalue problem. Students also analyze the motion due to changes in control variables. (A, E, K, L, N)

iii. Become proficient in the dynamic control of aircraft - This proficiency is gained through the learning of root locus techniques, PID control and its simplifications, and phase lead and lag methods. Students make extensive use of the Control Systems Toolbox of Matlab to implement and test control strategies. (A, E, I, K, L, N)
iv. Gain experience and confidence in designing and testing a control system for a real aircraft - After choosing an aircraft and flight conditions, students obtain aerodynamic data and perform a complete analysis of either the longitudinal or lateral dynamics. A control system, such as an autopilot, is designed and numerically simulated. (C, J, K, N)
v. Gain experience and confidence in writing reports on aircraft dynamics and control - Students produce an extensive two-part report that describes aircraft history, analysis, control design, and numerical simulations. (G, L)
vi. **Gain experience in taking and analyzing experimental data from a scaled 3DOF wing structure**. (B, N)

Course Learning Outcomes mapped to Program Outcomes:
(For Program Outcomes, please see attached page or Department Web Site)

Program:	A	B	C	D	E	F	G	H	I	J	K	L	M	N
Course:	i,ii, iii	vi	iv		i,ii, iii		v		iii	iv	ii,iii, iv	i,ii,iii, v		i-iv,vi
Emphasis:	5	2	3	1	5	1	2	1	2	2	3	4	1	5

Topics (time spent in weeks):
1. Aerodynamic forces and moments (0.5)
2. Static stability (2)
3. Aircraft equations of motion (1.5)
4. Stability derivatives (1)
5. Dynamic stability (1.5)
6. Laplace transform (1)
7. Feedback performance measures (0.5)
8. Feedback design using root locus (1.5)
9. Aircraft open-loop response (0.5)
10. Flying quality standards (USAF Spec. MIL-F-8785C) (0.5)
11. Longitudinal and lateral autopilots (3)
12. In-class exams (0.5)

Contribution of Course to Meeting the Professional Component:
Engineering Topics: 100%

Status of Continuous Improvement Review of this Course:
Prepared by: Hua Wang **Date:** March 27, 2009