AE 5302 – Advanced Flight Mechanics
Fall 2009

Instructor : Dr. Atilla Dogan
Class Days/Time : Mo,Wed,Fri 10:00-10:50AM
Classroom : Rm NH 112
Instructor's Office : Rm 315H WH
Office Hours : By appointment or Walk-in
Phone : (817) 272-3744
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Email : dogan@uta.edu
Instructor WWW : http://omega.uta.edu/~dogan/
Course Web Site : http://www.uta.edu/webct/
: You should login with your UTA NetID and password.
Course Prerequisites : Permission of department
Required Textbook : None (will use lecture notes)
Primary References: :

• B.L. Stevens and F. L. Lewis, *Aircraft Control and Simulation – 2nd Edition*, John Wiley & Sons, Inc., 2003.
• R.M. Murray, Z.Li, and S.S. Sastry, *A Mathematical Introduction to Robotic Manipulation*, CRC Press, 1994.
• D. McLean, *Automatic Flight Control Systems*, Prentice-Hall, 1990.
• A.E. Bryson, *Control of Spacecraft and Aircraft*, Princeton Univ. Press, 1994.

Course Description :

Basic dynamics of aerospace vehicles, flight path analysis and design, aircraft stability design and analysis.

Course Learning Goals/Objectives :

Develop conceptual understanding and technical insight into flight dynamics and flight control systems; introduction to advanced flight control concepts.

Attendance and Drop Policy :

Students are required to attend class and must notify the instructor if missing a class is necessary. See graduate catalog for drop policy

Course Content : (*tentative*)

- Rigid body motion
  - Orientation
    - Inertial coordinates and body coordinates
    - Rotation matrix and orientation parameterizations
      - Euler angles
      - Axis-angle variables
      - Quaternions
    - Properties of rotation matrices
  - Rotational kinematics
  - Translational kinematics

  - Newton-Euler equations
    - Rotational dynamics
    - Translational dynamics
  - Expressing equations of motion in various coordinate frames

- Aircraft equations of motion
  - Aircraft rotational and translational kinematic models
  - Aircraft rotational and translational dynamic models
  - Required model data
    - Aircraft data
    - Aerodynamic data
  - Nonlinear terms
  - Nonlinear approximate models
  - Trimmed flight maneuvers
  - Linearized approximate models
  - Expressing aircraft equations of motion in various coordinate frames
  - Advanced aircraft modeling issues
    - Wind models including wind shear
    - Flexible aircraft and aeroelastic effects

- Spacecraft equations of motion
  - Spacecraft rotational and translational kinematic models
  - Spacecraft rotational and translational dynamics models
  - Spacecraft attitude models
  - Nonlinear terms
  - Natural spacecraft motions and equilibrium conditions
  - Linearized models
  - Advanced spacecraft modeling issues
    - Spacecraft attitude models for circular orbit
    - Gravity gradient effects
    - Flexible spacecraft
    - Spacecraft with articulated appendages

- Aircraft control
  - Flight control variables
    - State variables
    - Aero control surfaces and throttle control
    - Output variables
  - Flight control performance measures
    - Handling qualities
    - Structural loads
  - Flight control problems
    - Longitudinal control
      - Cruise

        - Climb rate
        - Airspeed
      - Lateral control
        - Bank angle
      - Coordinated turns
  - Control design methodologies
    - LQG linear control
    - Robust linear control
    - Gain scheduling
    - Time scale methods
    - Feedback linearization and dynamic inversion
  - Advanced aircraft flight control issues
    - Control surface dynamics and limits
    - Aggressive maneuvers (not trimmed flight)
    - Thrust vectoring
      - High angles of attack
      - Tailless aircraft
    - Integrated propulsion and flight control
    - Control configured aircraft
      - Control mixing logic
    - Reconfigurable aircraft

- Spacecraft control (not likely but if time left)
  - Spacecraft control models: thrusters, reaction wheels, CMGs
  - Flight control objectives
  - Velocity stabilization
  - Attitude stabilization and tracking problems
  - Spin stabilization
  - Control design methodologies
    - Robust control
    - Lyapunov methods
    - Feedback linearization and dynamic inversion
  - Advanced spacecraft attitude control issues
    - Momentum management
    - Control of flexible spacecraft
    - Dual spin spacecraft
    - Control of spacecraft with articulated appendages

Specific Course Requirements w/ Descriptions :

- **Quizzes :** N/A
- **Examinations :** There will be no exam for the course

Major Assignments :

- **Homework :**
  Homework problem sets will be distributed throughout the semester. MATLAB/Simulink by Mathworks Inc will be needed for some of the homework solutions. Progress on the homework can be submitted on **October 12** and **November 23**, and preliminary evaluations and feedback (not grading) will be provided by the instructor. All final homework sets are due on **December 4 at 10 AM**.

- **Projects :**
  Choose a significant topic related to flight dynamics and/or flight control; typical topics include, but are not limited to, the following:

  ▷ Mass–varying aircraft, rocket and spacecraft systems
  ▷ Aircraft dynamics and control in wind and turbulence
  ▷ Formation Control
  ▷ Automatic Aerial Refueling
  ▷ Thrust vectoring control for tailless military aircraft
  ▷ Airship/Blimp dynamics and control
  ▷ Landing on aircraft carrier
  ▷ Control of coordinated aircraft turns
  ▷ High angle of attack rolling maneuvers
  ▷ Multiple engine control for a damaged commercial aircraft
  ▷ Integrated propulsion and flight control
  ▷ Control of bank to turn missiles
  ▷ Pilot induced oscillations
  ▷ Rotorcraft flight control
  ▷ Quadrotor flight modeling and control
  ▷ Air traffic control conflict prediction and resolution
  ▷ Rapid spacecraft slewing
  ▷ Gravity gradient effects on spacecraft attitude control
  ▷ Spacecraft attitude control using magnetic torquers
  ▷ Attitude control using pulse-width-modulated thrusters

  Investigate that topic by identifying relevant published literature, carry out dynamics and control analysis and design, and develop a written document summarizing your results and conclusions. Your investigation should include modeling, data collection, theoretical analysis, and computational approaches as applied to a specific aircraft or spacecraft vehicle.

  A decision of the project topic is due **September 14** (You should discuss the topic with the instructor before making your decision final). A two page topic proposal is due in class on **September 23**. In the proposal, you should clearly state the problem, why it is important, what has been reported in the literature, what specific topic you propose to address, how you propose to address it and what will be the deliverables of the project. Every other week, you must report to me the status of your project

progress. The final report is due on **November 20 at 10:00 AM**. Your final report should provide a summary of your results and conclusions, and be in the format of AIAA conference papers. You can download conference paper template from AIAA website. `Your report should not be longer than 10 pages.` Within the last two weeks of the semester, you should come to class to give a 15-minute presentation on your term project. The schedule of the presentations will determine by the instructor. *Your project will be evaluated on the basis of its compliance with your Sep-23 proposal, the quality of the technical development, its engineering merit, and the quality of the report and the presentation.*

Course Evaluation & Final Grade :

- Homeworks : 50%
- Project : 50%

Grade Allocation: Course grades will be earned based on the following criteria:

- 90–100 $\Longrightarrow$ A
- 80–89 $\Longrightarrow$ B
- 70–79 $\Longrightarrow$ C
- 60–69 $\Longrightarrow$ D
- other $\Longrightarrow$ F

UNIVERSITY POLICIES:

Email to/from Faculty - You should use emailing tool provided within WebCT environment to communicate with the instructor. The instructor will only use this tool to send email to the students. Within WebCT, you can set email forwarding to any other email address to receive emails sent to your webCT account. However, you should use WebCT email tool to send email to the instructor.

Student Evaluation of Teaching - You will be asked to complete feedback forms at the end of the semester.

Absences Based on Religious Beliefs - A student who misses an examination, work assignment, or other project due to the observance of a religious holy day will be given the opportunity to complete the work missed. To be eligible for such a make-up, the student must notify his/her instructor in writing within the first 15 days of class. Failure to follow the rules provided above within the time frames listed will result in the absence being considered unexcused.

Americans with Disabilities Act - The University of Texas at Arlington is on record as being committed to both the spirit and letter of federal equal opportunity legislation; reference Public Law 93112 – The Rehabilitation Act of 1973 as amended. With the passage of new federal legislation entitled Americans With Disabilities Act - (ADA), pursuant to section 504 of The Rehabilitation Act, there is renewed focus on providing this population with the same opportunities enjoyed by all citizens. As faculty members, we are required by law to provide "reasonable accommodation" to students with disabilities, so as not to discriminate

on the basis of that disability. Student responsibility primarily rests with informing faculty at the beginning of the semester and in providing authorized documentation through designated administrative channels. For more information contact the Office for Students with Disabilities at 917-272-3364.

Academic Dishonesty - It is the philosophy of The University of Texas at Arlington that academic dishonesty is a completely unacceptable mode of conduct and will not be tolerated in any form. Any person involved in academic dishonesty will be disciplined in accordance with University regulations and procedures. Discipline may include suspension or expulsion from the University. It is your responsibility to know University policies on these matters. "Scholastic dishonesty includes but is not limited to cheating, plagiarism, collusion, the submission for credit of any work or materials that are attributable in whole or in part to another person, taking an examination for another person, any act designed to give unfair advantage to a student or the attempt to commit such acts." (Regents' Rules and Regulations, Part One, Chapter VI, Section 3, Subsection 3.2, Subdivision 3.22)

Inclement Weather Policy - In the event that weather or other conditions are such that normal campus operations could be impeded the following policy will apply for this class. If the University is closed this class will not meet. Any assignments due or examinations scheduled will be due or rescheduled to the very next class period that the class meets. Local media should announce any closings. You can also get information by dialing (972) 601-2049.

Student Success - UTA supports a variety of student success programs to help you connect with the university and achieve academic success. They include learning assistance, developmental education, advising and mentoring, admission and transition, and federally funded programs. Students requiring assistance academically, personally, or socially should contact the Office of Student Success Programs at 817-272-6107 for more information and appropriate referrals.

Notice - The instructors reserve the right to make changes to the course syllabus as necessary. It is the student's responsibility to keep up with changes to the syllabus as posted on the class FTP site.