MAE 3405-001
FLIGHT DYNAMICS
Spring 2016
1:00PM-1:50PM MWF
2:00PM-2:50PM F
NH 109

Instructor(s): Baxter "Bob" Mullins, Jr., Ph.D.
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Course Description: *MAE 3405 FLIGHT DYNAMICS* (4-0) Derivation of equation of motion (EOM) of a flight vehicle. Trimmed flight condition analysis based on the nonlinear EOM. Linearization of EOM for a given trimmed flight condition. State-space and transfer-function representations of the linear EOM. Aircraft stability and dynamic performance analysis based on the linear EOM.

Course Prerequisites: MAE 3406 (or concurrent enrollment), C or better in MATH 3330

Student Learning Outcomes: With the successful completion of this course, the student shall have basic understanding of how to develop models for atmospheric flight vehicles, the short-falls of such models, and basic understanding of analysis techniques commonly used by industry. As this is a professional-level course, the professor shall be concerned with the student's response in meeting class requirements in a responsible, professional manner, considering both schedule and presentation. As such, industrial practices shall be included as part of the classroom, homework, and project activities with standard nomenclature and processes introduced and practiced. This shall include standard industrial practices developed by national and international agencies including ISO, Six Sigma, government (e.g., FARS, MIL STD) and professional organizations (e.g. AIAA, SAE).

Requirements: Class and exam attendance is mandatory. Students taking this course are expected to **arrive on time**, and to stay in class until they are dismissed. Students who fail to adhere to the attendance policy can expect an impact on their final grade. Reasons for absence must be documented in writing to the instructor. Homework assignments shall be included in computing the final grade; unless otherwise stated, all assignments are due at the beginning of the class on the date due. ***Late homework submission will not be accepted.*** Students are expected to do their own work and to provide homework and projects in required formats. Cell phones, computers, or other electronic devices must be turned off and stored during class unless otherwise permitted by instructor via written agreement. It is expected that each student shall take notes in class in a spiral bound notebook.

Descriptions of major assignments and examinations: In-class examinations will be given; all exams are comprehensive. There are no make-up exams. Should absence from an exam be excused, the final average for the course will be based on one less exam. Unless stated otherwise, all exams are closed book and a calculator is allowed. Key Assignments will be included as part of the exams and homework/project assignments and these key assignments must be passed to receive a passing grade for the course.

Reference Textbook: Yechout, Thomas R., *Introduction to Aircraft Flight Mechanics: Performance, Static Stability, Dynamic Stability, Classical Feedback Control, and State-Space Foundations, 2nd ed.,* AIAA Education Series, 1801 Alexander Bell Drive, Reston, VA 20191-4344, 2014.

References: Primary references are those texts and documents that have direct application to MAE 3405. Please note that you should review and read materials in these texts and documents as assigned. Some of the review material is indicated with the references documented, other material shall be assigned during class activities: Hibbeler, R.C., *Engineering Mechanics: Statics and Dynamics, 13th ed*., Pearson, Boston, 2013 (Chap 20 Three-Dimensional Kinematics of a Rigid Body, Chap 21 Three-Dimensional Kinetics of a Rigid Body) ; Zill, Dennis G., *Advanced Engineering Mathematics*, Jones and Bartlett Publishing, MA 2009 (Chap 4 The Laplace Transform, Chap 10 Systems of Differential Equations, Chap17 Complex Numbers); Bretscher, Otto, *Linear Algebra with Application, 5th ed*., Pearson, Boston, 2013; McRuer, D., Ashkenas, I., and Graham, D., *Aircraft Dynamics and Automatic Control*, Princeton University Press, 1990, ISBN 069102024405; Phillips, Warren F., *Mechanics of Flight – 2nd Edition*, John Wiley & Sons, Inc. 2010, ISBN 978-0-470-53975-0; Roskam, Jan, "Airplane Design, Part VI: Preliminary Calculation of Aerodynamic, Thrust and Power Characteristics," DARCorporation, Lawrence KS.and Chow, J., *Feedback Control Using MATLAB and the Control System Toolbox (Bookware Companion Series)*, Cengage Learning, 1999, or similar reference; Finch, RD, *USAF Stability and Control DATCOM*, ADB072483, AFWAL/FIGC, AFWAL, WPAFB , 1983; ANON, *Flying Qualities of Piloted Airplanes*, MIL-F-8785c, 1980.

Additional materials: ***Student Edition of MATLAB with Control Tool Box*** available at the UTA Bookstore, 5-subject spiral bound notebook for classroom notes.

Final Grade Computation. There will be 4 in-class exams (60%) and homework/projects (40%). Grades shall be posted on Black Board. It is the responsibility of the student to remain cognizant of their grade. Grade assignments: A (90-100), B (80-89), C (70-79), D (60-69), F (less than 60)

Grade Grievances: Any appeal of a grade in this course must follow the procedures and deadlines for grade-related grievances as published in the current University Catalog.

Expectations for Out-of-Class Study: Beyond the time required to attend each class meeting, students enrolled in MAE 3405, a 4-credit hour course, should expect to spend at least an additional 12 hours per week of their own time in course-related activities, including reading required materials, completing assignments, preparing for exams, etc. (The general rule of thumb is for every credit hour earned, a student should expect to spend 3-hours per week working outside of class.)

Drop Policy: Students may drop or swap (adding and dropping a class concurrently) classes through self-service in MyMav from the beginning of the registration period through the late registration period. After the late registration period, students must see their academic advisor to drop a class or withdraw. Undeclared students must see an advisor in the University Advising Center. Drops can continue through a point two-thirds of the way through the term or session. It is the student's responsibility to officially withdraw if they do not plan to attend after registering. **Students will not be automatically dropped for non-attendance**. Repayment of certain types of financial aid administered through the University may be required as the result of dropping classes or withdrawing. For more information, contact the Office of Financial Aid and Scholarships (http://wweb.uta.edu/aao/fao/).

Americans with Disabilities Act: The University of Texas at Arlington is on record as being committed to both the spirit and letter of all federal equal opportunity legislation, including the *Americans with Disabilities Act (ADA)*. All instructors at UT Arlington are required by law to provide "reasonable accommodations" to students with disabilities, so as not to discriminate on the basis of that disability. Any student requiring an accommodation for this course must provide the instructor with official documentation in the form of a letter certified by the staff in the Office for Students with Disabilities, University Hall 102. Only those students who have officially documented a

need for an accommodation will have their request honored. Information regarding diagnostic criteria and policies for obtaining disability-based academic accommodations can be found at www.uta.edu/disability or by calling the Office for Students with Disabilities at (817) 272-3364.

Special Needs: ***The instructor must be notified at the beginning of the semester (usually the first week) of any 'Special Needs Testing' requirements, such as testing.*** The student must be registered and approved for special testing allowances. If so, the student is responsible for obtaining and presenting the necessary forms to the instructor at least a week before any exam. (Quizzes are not covered under "special Needs Testing.")

Student Support Services: UT Arlington provides a variety of resources and programs designed to help students develop academic skills, deal with personal situations, and better understand concepts and information related to their courses. Resources include tutoring, major-based learning centers, developmental education, advising and mentoring, personal counseling, and federally funded programs. For individualized referrals, students may visit the reception desk at University College (Ransom Hall), call the Maverick Resource Hotline at 817-272-6107, send a message to resources@uta.edu, or view the information at www.uta.edu/resources.

Title IX: The University of Texas at Arlington is committed to upholding U.S. Federal Law "Title IX" such that no member of the UT Arlington community shall, on the basis of sex, be excluded from participation in, be denied the benefits of, or be subjected to discrimination under any education program or activity. For more information, visit www.uta.edu/titleIX.

Academic Integrity: Instructors may employ the Honor Code as they see fit in their courses, including (but not limited to) having students acknowledge the honor code as part of an examination or requiring students to incorporate the honor code into any work submitted. Per UT System *Regents' Rule* 50101, §2.2, suspected violations of university's standards for academic integrity (including the Honor Code) will be referred to the Office of Student Conduct. Violators will be disciplined in accordance with University policy, which may result in the student's suspension or expulsion from the University.

Electronic Communication: UT Arlington has adopted MavMail as its official means to communicate with students about important deadlines and events, as well as to transact university-related business regarding financial aid, tuition, grades, graduation, etc. All students are assigned a MavMail account and are responsible for checking the inbox regularly. There is no additional charge to students for using this account, which remains active even after graduation. Information about activating and using MavMail is available at http://www.uta.edu/oit/cs/email/mavmail.php. When sending e-mail provide in the subject line the course information, such as "***MAE 3405-001, plus a short description***" on subject of the email.

Student Feedback Survey: At the end of each term, students enrolled in classes categorized as "lecture," "seminar," or "laboratory" shall be directed to complete an online Student Feedback Survey (SFS). Instructions on how to access the SFS for this course will be sent directly to each student through MavMail approximately 10 days before the end of the term. Each student's feedback enters the SFS database anonymously and is aggregated with that of other students enrolled in the course. UT Arlington's effort to solicit, gather, tabulate, and publish student feedback is required by state law; students are strongly urged to participate. For more information, visit http://www.uta.edu/sfs.

Final Review Week: A period of five class days prior to the first day of final examinations in the long sessions shall be designated as Final Review Week. The purpose of this week is to allow students sufficient time to prepare for final examinations. During this week, there shall be no scheduled activities such as required field trips or performances; and no instructor shall assign any themes, research problems or exercises of similar scope that have a completion date during or following this week *unless specified in the class syllabus*. Standard homework may be assigned during this period that provides the student with an example of the classroom material

developed in the last week of instruction. During Final Review Week, an instructor shall not give any examinations constituting 10% or more of the final grade, except makeup tests and laboratory examinations. In addition, no instructor shall give any portion of the final examination during Final Review Week. During this week, classes are held as scheduled. In addition, instructors are not required to limit content to topics that have been previously covered; they may introduce new concepts as appropriate.

Emergency Exit Procedures: Should we experience an emergency event that requires us to vacate the building, students should exit the room and move toward the nearest exit, which is located by the elevators – DO NOT USE THE ELEVATORS, but the stairway across from the elevators. When exiting the building during an emergency, one should never take an elevator but should use the stairwells. Faculty members and instructional staff will assist students in selecting the safest route for evacuation and will make arrangements to assist individuals with disabilities.

Homework Format: Engineering Paper shall be used for all assigned homework/projects. Each assigned problem shall begin with a new page. The header shall include the student's last name, then first name, class information (MAE 3405-001), date, and page number information. All homework shall include the chapter-problem number and title, statement of the problem, knowns, requirements and appropriate diagrams followed by an organized solution to the problem including references to equations and methods used to solve the problem. Computer printout shall be attached behind a cover page with the appropriate problem description. The homework shall be folded in the middle and the bottom folded to the top. On the back of the homework, the student shall include the last and first name, followed in the next line by the class name (MAE 3405-001), Chapter number(s) and problem number(s), and finally due date. If multiple problems, list each separately. (an example shall be provided on blackboard.)

Important Dates: First day of class 01/19/16; Spring Vacation 03/14/16-03/18/16 (No class); Last day of class 05/05/16; and Final Exam 05/09/16 from 11:00 am – 1:30 pm. Additionally, three (3) 50-minute exams shall be given during the semester.

"As the instructor for this course, I reserve the right to adjust this schedule in any way that serves the educational needs of the students enrolled in this course. – Baxter R. Mullins, Jr."

Topics Covered:

- Review
  - Subject of Flight Mechanics
  - Static Stability and Control
  - Flying Qualities and the Human Pilot
  - Axes and Notation
- General Equations of Motion
  - Rules and Assumptions
  - Kinematic Equations
  - Rigid-body Equations of Motion
  - Evaluation of Angular Momentum
  - Elastic Degrees of Freedom
  - Effect of Spinning Rotors
  - Effect of non-zero wind
- Stability Derivatives
  - Longitudinal Derivatives
  - Lateral Derivatives
- Stability of Controls-Fixed Motion
  - Longitudinal Stick-Fixed
  - Lateral Stick-Fixed
- Stability of Controls-Free Motion
  - Longitudinal Controls-Free Motion
  - Lateral Controls-Free Motion
- Mathematical Tools
  - Small-Disturbance Theory
  - Linear System Theory
  - Laplace Transforms
  - Block Diagram Algebra
  - State-Space Formulation
- Actuation of Controls
- Closed-Loop Control (Introduction to Feedback Control)
  - Reduced Stability
  - Stability Augmentation Systems
- Every day "Rules of Thumb"

Emergency Phone Numbers: [Optional but strongly recommended] In case of an on-campus emergency, call the UT Arlington Police Department at **817-272-3003** (non-campus phone), **2-3003** (campus phone). You may also dial 911.

For non-emergencies, contact the UTA PD at 817-272-3381.