MAE 3405-001 Flight Dynamics Spring 2019

Instructor: Dr. Baxter R. Mullins, PE

Office Number: Woolf Hall, Rm #302

Office Telephone Number: 817-272-2896

Email Address: mullins@uta.edu

Faculty Profile: https://mentis.uta.edu/explore/profile/baxter-mullins

Office Hours: MTWT 4:00 p.m.- 5:00p.m. (other times by appointment)

Section Information: MAE 3405-001 Time and Place of Class Meetings: NH, Rm #229, MW 1:00-1.50 PM NH, Rm #108, F 1:00-2:50 PM

Description of Course & Structure

As one of your courses in the professional portion of your engineering degree plan, the format of **MAE 3405 Flight Dynamics** course will be somewhat different than what you have experienced in your sciences and mathematics courses. This course is structured to provide the student the necessary fundamentals of solving engineering problems with an "industrial perspective" of the material and its use in that environment. The instructor will be your "customer/client/manager" and you, the student, are the "engineer" providing the requested analysis and presentation of the results in an organized manner based on standard practices and processes. The intent is to prepare the student to quickly perform at a high level in industry upon graduation. To that end there are very specific processes to be followed and an expected quality of work products.

Description of Course Content

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.

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 a basic understanding of how to develop and model physical systems, analyze system behavior, and develop simplified control techniques, the short falls of such models, and basic understanding of analysis techniques commonly used. 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. ASME, AIAA, SAE, etc.).

The course content will include (not necessarily in order):

- 1. Problem Solving Methods and Processes
- 2. Review
 - a. Rigid-Body Mechanics
 - b. Aerodynamics
 - c. Static Stability and Control
 - d. Axes and Notation
- 3. General Equations of Motion
 - a. Rules and Assumptions
 - b. Kinematic Equations
 - c. Rigid-body Equations of Motion
 - d. Evaluation of Angular Momentum
 - e. Elastic Degrees of Freedom
 - f. Effect of Spinning Rotors
 - g. Effect of wind
- 4. Stability Derivatives
 - a. Longitudinal Derivatives
 - b. Lateral Derivatives
 - c. Determination of Stability Derivatives
- 5. Mathematical Analysis Techniques
 - a. Small-Disturbance Theory
 - b. Linear System Theory
 - c. Laplace Transforms
 - d. Block Diagram Algebra
 - e. State-Space Formulation

- 6. Transfer Functions
 - a. Definition
 - b. Computation
 - c. Examples
 - d. Pole-zero Diagrams
 - e. State-space Models
 - f. Natural Flight
 - g. Stick-Fixed Longitudinal Flight
 - h. Stick-Fixed Lateral Flight
- 7. Trimmed Flight Conditions
 - a. Equilibrium or Steady-State Conditions
 - b. Nonlinear Algebraic Equations
- 8. Design Requirements (Flying Qualities)
 - a. Cooper-Harper
 - b. Design Requirements
 - c. DoD and FAA Requirements
- 9. Time Domain Performance
 - a. 1st-order systems (1st order longitudinal and lateral flight modes)
 - b. 2nd-order systems (2nd order longitudinal and lateral flight modes)
- 10. Closed-Loop Control
 - a. Introduction to Reduced Stability
 - b. Discussions Stability Augmentation Systems

Every day "Rules-of-Thumb", will be presented and discussed throughout the semester.

Theory formulation, variable definition, analysis procedure and results presentation will follow industry standards. 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).

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 and model physical systems, analyze system behavior, and develop simplified control techniques, the short falls of such models, and basic understanding of analysis techniques commonly used. As this is a professional-level course, the instructor 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. ASME, AIAA, SAE, etc.).

Textbooks and Other Course Materials

- Phillips, Warren F., *Mechanics of Flight 2nd ed*, John Wiley & Sons, Inc. 2010, ISBN 978-0-470-53975-00 is the departments required text but will be used sparingly for some reading assignments.
- Instructor notes.
- Engineering Paper or Quad-Ruled Paper, Drawing Tools (ruler 6" will suffice, protractor, compass)

Software: You may use any computer software that you like and there are a many available such as SCILAB http://www.scilab.org, Mathematica http://www.wolfram.com, LabVIEW http://www.ni.com, MATLAB/SIMULINK[®] http://www.mathworks.com, and many others. Make sure that you can have access to the software during the semester and you are proficient in it for the purposes of this class. Instructor will primarily use CC5.

References:

- McRuer, D., Bates, C.L., and Ashkenas, I., *Dynamics of the Airframe*, NORAIR/BU AER, Report AE-6-4-II, September 1952. (An open literature version is provided on Blackboard)
- Roskam, Jan, *Airplane Flight Dynamics and Automatic Flight Controls Pt. 1&2*, DARCorporation, Lawrence KS. (Kindle Available)
- Roskam, Jan, *Airplane Design: Preliminary Calculation of Aerodynamic, Thrust and Power Characteristics (Airplane Design Series VI)* (Kindle), DARCorporation, Lawrence KS. (Kindle addition)
- Roskam, Jan, *Airplane Aerodynamics and Performance*, DARCorporation, Lawrence KS, 2016. (Kindle addition)
- Napolitano, Marcello R., *Aircraft Dynamics: From Modeling to Simulation*, John Wiley & Sons, Inc., New York, Inc., 2012. (Kindle Available)
- 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, VA 20191-4344, 2014.
- Perkins, C. D. & Hage, R. E., *Airplane Performance, Stability and Control*, John Wiley & Sons, New York, 1949.
- Etkin, B, *Dynamics of Flight: Stability and Control*, John Wiley & Sons, 1959 or 1964.
- McRuer, D., Ashkenas, I., and Graham, D., *Aircraft Dynamics and Automatic Control*, Princeton University Press, 1990, ISBN 069102024405. (An open literature version is provided on Blackboard)
- Chow, J., *Feedback Control Using MATLAB and the Control System Toolbox* (Bookware Companion Series), Cengage Learning, 1999, or similar MATLAB[®] reference
- Finch, RD, USAF Stability and Control DATCOM, ADB072483, AFWAL/FIGC, AFWAL, WPAFB, 1983
- ANON, *Flying Qualities of Piloted Airplanes*, MIL-F-8785c, 1980.

Descriptions of major assignments and examinations

Exams

• Two (2) exams and a comprehensive final exam. (May 10th, 11-1:30pm)

Key Assignment for Outcome E - "an ability to identify, formulate and solve engineering problems."

Assignments:

- Assignments will be made throughout the semester.
- Assignments <u>must</u> follow the format provided on Blackboard and Blackboard and must be readable and presented in a professional manner. When evaluated, failure to follow this format will result in a "zero" grade for that assignment.
- Each problem will include a (1) Problem Statement (Statement of Work) with appropriate sketches, (2) Problem "Knowns", (3) Problem Requirements, (4) Solution Approach, (5) Solution with equations, references and all necessary work to completely describe the solution, and (6) Answers will be Boxed. Computer programs, output, graphs, etc. will be attached to the solution. The top of each page of the assignment will have your Last Name, First Name, Class Information, and Date Due. Complete format requirements with examples can be found on BlackBoard. When evaluated/graded, failure to follow the format will result in a "zero" grade for that assignment.
- Project format will be provided on BlackBoard for project written and oral report(s).
- Assignments shall be presented on engineering paper using the front-side of the paper only.
- Homework and Projects shall be assigned throughout the semester.
- Homework and Projects are due as specified by the instructor.

NOTE: For Homework & Projects, graphs/plots shall follow standard engineering formats. Chart Titles, Axis Titles, Legends, Scales and increment values, Grids and Tick marks, Descriptive textbox with pertinent information, etc. Failure to follow all the guidelines will result in a "zero" for item. An example of an engineering graph with annotations is provided in Blackboard.

Assignments - Graphs/plots shall follow standard engineering formats. Chart Titles, Axis Titles, Legends, Scales and increment values, Grids and Tick marks, Descriptive textbox with pertinent information, etc. Failure to follow all the guidelines will result in a "zero" for item. An example of an engineering graph with annotations is provided on Blackboard.

Attendance: At The University of Texas at Arlington, taking attendance is not required but attendance is a critical indicator in student success. Each faculty member is free to develop his or her own methods of evaluating students' academic performance, which includes establishing course-specific policies on attendance. As the instructor of this section, I will take attendance based on a seating chart established the first day of classes. Students arriving late to class maybe considered absent. However, while UT Arlington does not require instructors to take attendance in their courses, the U.S. Department of Education requires that the University have a mechanism in place to mark when Federal Student Aid recipients "begin attendance in a course." UT Arlington instructors will report when students begin attendance in a course as part of the final grading process. Specifically, when assigning a student a grade of F, faculty report the last date a student attended their class based on evidence such as a test, participation in a class project or presentation, or an engagement online via Blackboard. This date is reported to the Department of Education for federal financial aid recipients. *The policy for this class is that attendance will be taken*.

Students are expected to attend every class, to arrive on time, and to stay in class <u>until they are dismissed</u>. Students who fail to adhere to the attendance policy can expect an impact on their grade. Attendance will be considered in the assignment of the final letter grade. Students will not be penalized in the case of an emergency or an incident beyond the student's control.

Grading

•	First Trimester Exam:	25%
•	Second Trimester Exam:	25%

- Final Exam: 30%
- Assignments: 20%
- Grade Allocation: Letter grades will be assigned by the following ranges

 A (85-100), B (75-84), C (65-74), D (55-64), F (less than 55)
 Note that no incomplete grade will be given unless prior arrangements are made and in extreme circumstances.

As grades are assessed, they will be posted on Blackboard for the students to review. Students are expected to track of their performance throughout the semester and seek guidance from available sources beginning with your instructor and GTA if their performance drops below satisfactory levels. The instructor and GTA will be available to assist all students during regular office hours or by appointment.

Exam & Assignment Policy

Homework (5-point basis): The purpose of the homework is to provide practice exercises that apply the theory and concepts presented in class in order to identify and improve on any deficiencies that might exist. It could be either analytical and/or computational. Not all HW problems will be graded. It is your responsibility to attempt, solve and understand the assigned homework. Late homework will not be accepted.

Descriptions of major assignments and examinations

Semester Exams: There will be two comprehensive exams given during the semester. They may consist of two parts (an analytical and a computational). Note that part or the whole exam may be take-home. Any inclass exam will be closed book-notes-electronic device. The distance learning students must make arrangements to take the exam at the same time or day as the on-campus students.

Final Exam: The final exam will be comprehensive and may consist of two parts; an analytical and a computational and will be closed book-notes-electronic device. The exam will be given at the university scheduled time. Distance learning students must make arrangements to take the final at the same time or day as the on-campus students. If there will be a computational part, it could be given the last week of classes.

Makeup Exam: No makeup exams will be given unless I am notified in advance and approve of it. There will be only one comprehensive makeup exam the last week of the semester.

Special Needs

The instructor <u>must</u> be notified at the beginning of the semester, **within the first week of class**, by any student requiring **'Special Needs'** exam testing. The student must be registered and approved for special testing allowances. If so, the student is responsible for obtaining and presenting the necessary confirmation forms to the instructor in that first week. Additionally, **the student is responsible for coordinating all "special needs testing" with the test center <u>two weeks before each exam</u>. This includes coordinating with the instructor the date and time of the alternate test.** Per the university procedures, the testing center will contact the instructor and arrange the necessary private test schedule after the student has coordinated with

the test center and the instructor. Failure to meet these requirements will negate any "special needs testing" for that exam.

Course Schedule

Spring session begin on January 14, 2019, and ending on May 3, 2019, with final exam held from May 10, 2019. Holidays include MLK Day on January 21, 2019, and Spring Break March 11-16, 2019. A class schedule will be provided on Blackboard. Exam dates and reading assignments are provided. Homework, assignments and project assignments will be updated on a continuous basis. Homework not handed in before the beginning of class on the date due will be considered late and assigned a grade of zero.

Use of Electronic Devices

- Cellphone use in class is prohibited. They must be turned off and stored during class.
- No internet capable devices (i.e. laptops, tablet devices or calculators) can be used during exams.
- Only simple, hand calculators (non-smart devices) are permitted during class exams.
- Laptops, tablet devices, etc. (but no cellphones) may be used during lectures for taking personal notes with <u>written permission</u> of the instructor. Any other use of electronic devices will nullify any agreement allowing personal note taking on such devices.
- No audio and/or video recordings by the students are permitted.
- All audio devices such as headphones, earbuds, etc., must be turned off and stored during class time.

Expectations for Out-of-Class Study

Beyond the time required to attend each class meeting, students enrolled MAE 3405, a 4-credit hour course, should expect to spend <u>at least an additional 12 hours per week of their own time</u> 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 at minimum 4 hours per week working outside of class.)

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 undergraduate catalog. For undergraduate courses, see http://catalog.uta.edu/academicregulations/grades/#undergraduatetext; for graduate courses, see http://catalog.uta.edu/academicregulations/grades/#undergraduatetext; for graduate courses, see http://catalog.uta.edu/academicregulations/grades/#graduatetext; For student courses, see http://catalog.uta.edu/academicregulations/grades/#graduatetext. For student complaints, see http://www.uta.edu/deanofstudents/student-complaints/index.php

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/ses/fao).

Disability Accommodations

UT 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), The Americans with Disabilities Amendments Act (ADAAA),* and *Section 504 of the Rehabilitation Act.* 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 disability. Students are responsible for providing the instructor with official notification in the form of **a letter certified** by the Office for Students with Disabilities (OSD). Only those students who have officially documented a need for an accommodation will have their request honored. Students experiencing a range of conditions (Physical, Learning, Chronic Health, Mental Health, and Sensory) that may cause diminished academic performance or other barriers to learning may seek services and/or accommodations by contacting:

<u>The Office for Students with Disabilities, (OSD)</u> <u>www.uta.edu/disability</u> or calling 817-272-3364. Information regarding diagnostic criteria and policies for obtaining disability-based academic accommodations can be found at <u>www.uta.edu/disability</u>.

<u>Counseling and Psychological Services, (CAPS)</u> www.uta.edu/caps/ or calling 817-272-3671 is also available to all students to help increase their understanding of personal issues, address mental and behavioral health problems and make positive changes in their lives.

Title IX Policy: The University of Texas at Arlington ("University") is committed to maintaining a learning and working environment that is free from discrimination based on sex in accordance with Title IX of the Higher Education Amendments of 1972 (Title IX), which prohibits discrimination on the basis of sex in educational programs or activities; Title VII of the Civil Rights Act of 1964 (Title VII), which prohibits sex discrimination in employment; and the Campus Sexual Violence Elimination Act (SaVE Act). Sexual misconduct is a form of sex discrimination and will not be tolerated. *For information regarding Title IX, visit* www.uta.edu/titleIX or contact Ms. Jean Hood, Vice President and Title IX Coordinator at (817) 272-7091 or jmhood@uta.edu.

Academic Integrity

Students enrolled all UT Arlington courses are expected to adhere to the UT Arlington Honor Code:

"I pledge, on my honor, to uphold UT Arlington's tradition of academic integrity, a tradition that values hard work and honest effort in the pursuit of academic excellence. I promise that I will submit only work that I personally create or contribute to group collaborations, and I will appropriately reference any work from other sources. I will follow the highest standards of integrity and uphold the spirit of the Honor Code."

UT Arlington faculty members 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.

Lab Safety Training: No lab training is required for this course.

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.

Campus Carry

Effective August 1, 2016, the Campus Carry law (Senate Bill 11) allows those licensed individuals to carry a concealed handgun in buildings on public university campuses, except in locations the University establishes as prohibited. Under the new law, openly carrying handguns is not allowed on college campuses. For more information, visit <u>http://www.uta.edu/news/info/campus-carry/</u>

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

For semester-long courses, 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*. 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 at the ends of the hallway. 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. (See map next page)

If you are a student with physical/sensory disabilities, you should arrange to meet with me *in private* to discuss your needs for assistance in the event of an emergency evacuation.

Students should also be encouraged to subscribe to the MavAlert system that will send information in case of an emergency to their cell phones or email accounts. Anyone can subscribe at https://mavalert.uta.edu/ or https://mavalert.uta.edu/

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 <u>tutoring</u>, <u>major-based learning centers</u>, developmental education, <u>advising and mentoring</u>, personal counseling, and <u>federally funded programs</u>. 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 <u>resources@uta.edu</u>, or view the information at http://www.uta.edu/universitycollege/resources/index.php. The <u>IDEAS Center</u> (2nd Floor of Central Library) offers **FREE** <u>tutoring</u> to all students with a focus on transfer students, sophomores, veterans and others undergoing a transition to UT Arlington. To schedule an appointment with a peer tutor or mentor email IDEAS@uta.edu or call (817) 272-6593.

The English Writing Center (411LIBR): The Writing Center Offers **FREE** <u>tutoring</u> in 20-, 40-, or 60-minute faceto-face and online sessions to all UTA students on any phase of their UTA coursework. Our hours are 9 am to 8 pm Mon.-Thurs., 9 am-3 pm Fri. and Noon-6 pm Sat. and Sun. Register and make appointments online at <u>http://uta.mywconline.com</u>. Classroom Visits, workshops, and specialized services for graduate students are also available. Please see <u>www.uta.edu/owl</u> for detailed information on all our programs and services.

The Library's 2nd floor Academic Plaza offers students a central hub of support services, including IDEAS Center, University Advising Services, Transfer UTA and various college/school advising hours. Services are available during the library's hours of operation. <u>http://library.uta.edu/academic-plaza</u>

Librarian to Contact: Martin Wallace, martin.wallace@uta.edu, (817) 272-5127

Course Schedule

Course schedule is provided in Blackboard. Schedule will be updated as necessary to meet requirements.

"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. – Dr. Baxter R. Mullins."

COPYRIGHT

Copyright^(C) 2019 UTA COE as to this syllabus, all lectures, and all course materials. Students are prohibited from selling; notes taken during this course, provided course materials, or provided software. Students are also prohibited from being paid by any person or commercial firm for these materials without the express written permission of the professor teaching this course.

Emergency Phone Numbers: 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. Non-emergency number 817-272-3381

LIBRARY library.uta.edu

Resources for Students

Academic Help

- Academic Plaza Consultation Services library.uta.edu/academic-plaza
- Ask Us ask.uta.edu/
- Library Tutorials library.uta.edu/how-to
- Subject and Course Research Guides libguides.uta.edu
- Subject Librarians library.uta.edu/subject-librarians

Resources

- A to Z List of Library Databases libguides.uta.edu/az.php
- Course Reserves pulse.uta.edu/vwebv/enterCourseReserve.do
- FabLab fablab.uta.edu/
- Special Collections library.uta.edu/special-collections
- Study Room Reservations openroom.uta.edu/

MAE 3405-001 – Flight Dynamics Spring Semester 2019 Baxter R. Mullins. • Room 302WH • Tel: 817-272-2896 • E-Mail: mullins@uta.edu

Flight Dynamics

MAE 3405-001 **4 HOURS CREDIT**

SPRING 2019

SYLLABUS

By signing this syllabus, the student acknowledges that he/she has read and understood this document. Signature is due 01/21/2019.

Print Name: _____

Student ID: _____

Signature: _____ Date: _____

Prepared by: Baxter R. Mullins Date: 14 January 2019