MAE 3405-001 Flight Dynamics
Spring 2017

**Instructor:** Baxter R. (Bob) Mullins, Jr., Ph.D., P.E., S.S.B.B.

**Office Number:** Woolf Hall, Rm #302

**Office Telephone Number:** 817-272-2896

**Email Address:** mullins@uta.edu

**Office Hours:** W 2:00 – 3:00 PM, TT 4:00 – 5:00 PM (other times by prearranged appointment)

**Section Information:** MAE 3405-001

**Time and Place of Class Meetings:** WH, Rm #208, MW 1:00-1.50 PM
WH, Rm #210, F 1:00-2:50 PM

**Students will be required to have an "*iClicker II*" device for attendance and quizzes.**

- Students are required to register the ***iClicker II*** to this course in Blackboard.

**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.

The course content will include:

1. Problem Solving Methods and Processes
2. Review
    a. Flight Mechanics
    b. Static Stability and Control
    c. 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 Amplitude/Linearization Methods
   b. Laplace Transforms
   c. Transfer Functions
   d. Time Response Methods
   e. Matrix Methods
   f. Stability Methods
   g. Frequency Response Methods
   h. System Type and Errors
   i. Root Locus Methods
6. Stability of Controls-Fixed Motion
   a. Longitudinal Stick-Fixed
   b. Lateral Stick-Fixed
7. Stability of Controls-Free Motion
   a. Longitudinal Controls-Free Motion
   b. Lateral Controls-Free Motion
8. Design Requirements
   a. Flying Qualities
      i. Cooper-Harper
      ii. Requirements
   b. DoD and FAA Requirements
9. Mathematical Tools
   a. Small-Disturbance Theory
   b. Linear System Theory
   c. Laplace Transforms
   d. Block Diagram Algebra
   e. State-Space Formulation
10. Actuation of Controls
11. Closed-Loop Control (Introduction to Feedback Control)
   a. Reduced Stability
   b. 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 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).

**References and Other Course Materials**

- 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. (Primary Reference)
- Roskam, Jan, ***Airplane Flight Dynamics and Automatic Flight Controls Pt. 1&2***, DARCorporation, Lawrence KS.
- Roskam, Jan, ***Airplane Design: Preliminary Calculation of Aerodynamic, Thrust and Power Characteristics (Airplane Design Series VI)*** (Paperback), DARCorporation, Lawrence KS.
- 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)
- Phillips, Warren F., ***Mechanics of Flight – 2nd ed***, John Wiley & Sons, Inc. 2010, ISBN 978-0-470-53975-00.
- Blakelock, John H., ***Automatic Control of Aircraft and Missiles, 2nd ed.***, Wiley & Sons, 1991.
- Etkin, B, ***Dynamics of Flight: Stability and Control***, John Wiley & Sons, (any Version.)
- Etkin, B., ***Dynamics of Atmospheric Flight***, Wiley & Sons, (any version.)
- 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
- 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

- 3 – 50 min exams.
- 1 – Final Exam – 2 hr. and 30 min. (Scheduled on May 9th from 5:30-8:00 PM in the classroom.)
  - Comprehensive, i.e. all items within the course content list (see above)

Quizzes – Reading Assignment

Five (5)-min quizzes will be given (generally one per week…on any MWF) over the reading assignments for that day.

Homework & Projects

- Homework will be assigned throughout the semester.

- Homework must follow the homework format which is provided in Blackboard. When evaluated/graded, failure to follow this format will result in a "zero" grade for that assignment.
- Due dates will be provided at the time of the assignment.
- Assigned homework is due at the beginning of class on the date due.
- Projects will consist of problems encountered by engineers in their normal day-to-day activities. They may be single and team assignments at the discretion of the instructor.
- The student will maintain a homework notebook (3-ring notebook) with all the worked assignments in assigned order, separated by dividers (i.e. HW #1, HW #2, etc.) This notebook may be requested randomly for a review of the number of completed homework assignments and the grading of selected homework assignments to that date. The notebook will be returned after each review. The homework notebook will be turned in during the last week of the semester for a final review and homework grade determination. The final homework grade will be determined by the number of completed assignments relative to the total number of assignments and the average of the graded assignments. The notebook will available for pickup at the end of finals.

**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.

**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. 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.

Students taking this course are expected to attend every class, 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 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. Attendance will be taken at the beginning of each class using an "***iClicker II***" device. Student is required to activate and register "***iClicker II***" with ***Blackboard***.

**Grading**

- Final Grade Weighting:

| | |
|---|---|
| Homework: | 30% |
| Projects (single or teamed projects): | 10% |
| 5-min quizzes: | 10% |
| Mid Term Exam: | 30% |
| Final Examination: | 20% |

- Grade Allocation: Letter grades will be assigned by the following ranges
  A (90-100), B (80-89), C (70-79), D (60-69), F (less than 60)

In order to receive a passing grade ("C" for an Engineering major), the weighted average (see above) of the homework, computer projects, mid-term and the final examination must be 70 or above.

As grades are assessed, they will be posted on Blackboard for the students to review. Students are expected to keep track of their performance throughout the semester and seek guidance from available sources (including the instructor) if their performance drops below satisfactory levels.

**Homework & Project Policy**

- See homework and project descriptions above.

**Exam & Quiz Policy**

**Quizzes**

- **All quizzes are "closed-book, closed-notes".**
- There will be **NO** make-up quizzes. **Missed quizzes will receive a grade of zero**.

**Exams**

- All problems stated in the exams will be weighted equally unless otherwise specified.
- **All exams are "closed-book, closed-notes".** No internet capable devices (i.e. laptops, tablet devices or calculators) can be used during exams. Only simple, hand calculators are permitted during class exams. (see **Use of Electronic Devices** section of the syllabus)
- Students will be allowed a single-sided, 8.5x11 piece of paper (i.e. no writing on the back of the paper) with their personal exam notes, formulas, etc. Failure to follow these instructions will result in confiscation of the formula sheet. The formula sheet will be turned in with its corresponding exam as part of the exam. **Failure to turn in the formula sheet will result in a grade of zero for the exam.**
- There will be **NO** make-up exams for unexcused absences. **Missed exams will receive a grade of zero**.
- A student having an **UNEXCUSED** absence from the final exam will receive the course grade earned.
- A student having an **EXCUSED** absence from the final exam has two options:
    1. The student may elect to receive the course grade earned with the final exam grade equal to zero, or
    2. The student may elect to receive the grade of "I" (incomplete) and make arrangements to complete the course by taking the final examination at the end of the next semester.
    - If the student chooses the second option, it is the student's responsibility to consult with the instructor regarding completion of the course requirements.
    - NOTE: Excuses for absences from the final exam must be in writing with appropriate verification; e.g., note from your doctor, dentist, etc.

**Special Needs**

- The instructor must 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 two weeks before each exam**. **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**

A course schedule will be provided in Blackboard. Exam dates are provided on the schedule. Reading assignments, homework assignments, project assignments will be updated on a continuous basis. Homework assignments will be assigned weekly and uploaded to Blackboard.

**Use of Electronic Devices**

- Cellphone use in class is prohibited.
- No internet capable devices (i.e. laptops, tablet devices or calculators) can be used during exams.
- Only simple, hand calculators are permitted during class exams.
- *"**iClicker II**"* devices will be used for attendance and quizzes.
- Laptops, tablet devices, etc. may be used during lectures for taking personal notes.
- **No audio and/or video recordings by the students are permitted.** (Class lectures will be recorded and access provided to the students by the university via ECHO 360.)

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

**Counseling and Psychological Services, (CAPS)** 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 http://www.uta.edu/news/info/campus-carry/

**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.

**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 http://www.uta.edu/universitycollege/resources/index.php.

The IDEAS Center (2nd Floor of Central Library) offers free tutoring 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 tutoring in 20-, 40-, or 60-minute face-to-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 http://uta.mywconline.com. Classroom Visits, workshops, and specialized services for graduate students are also available. Please see www.uta.edu/owl 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. http://library.uta.edu/academic-plaza

**Library Home Page 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/

**Teaching & Learning Services for Faculty**

- Copyright Consultation library-sc@listserv.uta.edu
- Course Research Guide Development, Andy Herzog amherzog@uta.edu or your subject librarian
- Data Visualization Instruction, Peace Ossom-Williamson peace@uta.edu
- Digital Humanities Instruction, Rafia Mirza rafia@uta.edu
- Graduate Student Research Skills Instruction, Andy Herzog amherzog@uta.edu or your subject librarian
- Project or Problem-Based Instruction, Gretchen Trkay gtrkay@uta.edu
- Undergraduate Research Skills Instruction, Gretchen Trkay gtrkay@uta.edu or your subject librarian.

**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 website.**

*MAE 3405-001 – Flight Dynamics*
Spring Semester 2017
Baxter R. Mullins, Jr. • Room 302WH • Tel: 817-272-2896 • E-Mail: *mullins@uta.edu*

**Flight Dynamics**

**MAE 3405-001**
**4 HOURS CREDIT**

**SPRING 2017**

***SYLLABUS***

By signing this syllabus, the student acknowledges that he/she has read and understood this document.

Print Name: _____

Signature: _____ Date: _____

Prepared by: Baxter R. Mullins, Jr.
Date: 14 January 2017