SYLLABUS FOR MAE 3304-001, ASTRONAUTICS I

Catalog Description: MAE 3304: ASTRONAUTICS I (3-0) 3 hours credit. Introduction to astronautics, the solar system, and the two-body problem. Engineering approximation for orbital transfers and vehicle staging of powered trajectories. The single vehicle to orbit problem. Design considerations for earth satellites. Prerequisites: MAE 2323 and MAE 3360.

Instructor: Dr. Kamesh Subbarao, Assistant Professor, Mechanical and Aerospace Engineering Dept., 315 G Woolf Hall,(817) 272 7467, Office hours: By Appointment, Email: subbarao@uta.edu

Teaching Assistant: TBA

Recommended: Orbital Mechanics: For Engineering Students (Aerospace Engineering) (Hardcover) by Howard Curtis; Publisher: Butterworth-Heinemann (December 27, 2004); ISBN-10: 0750661690; ISBN-13: 978-0750661690

Additional references:

1. Introduction to Space Flight, by Francis J. Hale, Prentice Hall
2. William E. Wiesel, Spaceflight Dynamics, ISBN 0070701105 Publisher McGraw-Hill Science/Engineering/Math
3. Bate, Roger R.; White, Jerry E.; Mueller, Donald, Fundamentals of Astrodynamics, ISBN: 0486600610, Publisher: Dover Publications, Publication Date: 12/1971, 455 pages
4. Hanspeter Schaub, John L. Junkins, Analytical Mechanics of Space Systems AIAA Education Series, Published by AIAA, 2003, 600 pages, Mixed media ISBN: 1-56347-563-4
5. David Vallado, Fundamentals of Astrodynamics and Applications, 2nd. ed. (The Space Technology Library)
6. Spacecraft Attitude Dynamics and Control, Wertz (ed.), D. Reidel Publishing, 1978

Course Web Page:
http://www3.uta.edu/faculty/subbarao/Astronautics.html

Class Schedule: Three fifty-minute classes per week. MWF - 9.00 - 9.50 A.M. *Contribution of course to meeting the professional component: Engineering science - 3 hours credit.*

Course Description:

This course will provide a working knowledge in orbital mechanics, mission analysis and design, and satellite attitude dynamics and control.

The first part of the course deals with orbital mechanics. We will focus on the two-body problem, but the effects of perturbations such as non-spherical Earth and atmospheric drag will be covered. The emphasis of the course will be on the physics and the use of the equations in solving problems. Topics to be covered in orbital mechanics include orbit transfer, relative motion, and interplanetary trajectories. (roughly 60%)

The second part of the course will focus on boost vehicle performance and multi-stage launch vehicle design issues, atmospheric re-entry and heating problems. The focus here is to be able to gain sufficient

working knowledge to be able to address the practical issues. (roughly 20%)

The third part of the course deals with the attitude dynamics and control. The primary topics are single spin satellites, dual spin satellites, gravity gradient stabilization and active control. (roughly 20%).

You are encouraged to use STK and MATLAB software for solving homework problems.

Course Learning Objectives: At the end of this course, you should be able to:

1. Transform from orbital elements to satellite position and velocity and vice versa
2. Find the principal effects of perturbations on a satellite.
3. Design preliminary orbits for a specific mission
4. Determine the relative motion of two neighboring satellites.
5. Given two coplanar orbits determine the 2-impulse transfer between them.
6. Design interplanetary orbit transfers
7. Determine the fuel requirements for station keeping of geo-synchronous satellites.
8. Determine various stage factors for a multi-stage launch vehicle.
9. Given the definition of a set of Euler angles determine the coordinate transformation and the angular velocity.
10. Design notional attitude control laws for satellites.
11. Compute the disturbance gravitational torques on a satellite.
12. Do a preliminary design of the attitude control system for pointing requirements.

Tentative Course Topics

1. Vector differentiation, coordinate transformation, angular velocity, relative motion, angular momentum, and energy.
2. The two body problem: Kepler laws, Energy, Cartesian to orbital and vice-versa, circular orbits, orbit shaping, plane changes and escape.
3. Earth Operations: Hohmann, and non-Hohmann transfers. Transfer to geo-synchronous orbit. Evaluate the launch to rendezvous, and relative motion. Geo-Synchronous station keeping requirements.
4. Interplanetary trajectory: Sphere of influence, Impact Parameter, Launch windows and mission duration. Planetary fly-by and optimal planetary capture.
5. Vehicle and Booster Performance, Staging, Atmospheric Entry, Heating Problem, Ballistic Missile.
6. Attitude parameterization, Orbital elements, Orbit determination
7. Attitude dynamics: torque-free attitude dynamics. Spin stability.(single spin, dual spin), Dynamics with reaction or momentum wheels, Gravity gradient stability.
8. Attitude control: Overview and types of control systems, Attitude sensors and actuators, System responses to disturbances, Active and Passive Control methods.

Course Requirements:

Attendance- Students are expected to attend class! Timely attendance is expected.

Assignments/Quizzes- A number of homework assignments will be given during this course. The main aim of the assignments is to allow you to gain further insight into the concepts discussed and application of the same to typical problems. **Homework is due in class on the assigned date before the actual class begins. Late homework will not be accepted, unless in cases of unforseen circumstances such as medical conditions. Each such instance will be dealt with on a case by case basis.** Quizzes will be based on the homework assignments (including the reading assignments) so it is encouraged that you take these assignments seriously. Homework, quizzes and participation account for 20% of the total course grade.

Key Assignments There will be **two** such assignments in this course that must be passed in order to pass the course. In order to pass the class, you have to submit these key assignments and score a minimum of 50% on them. An opportunity to make up for a failed grade in these specific assignments will be provided and you are required to score a minimum of 50% on the make-up assignments as well. If any key assignment is not submitted or you fail to obtain the necessary score, you will not pass the class even if you score perfectly on all other exams and other assignments.

Key Assignment-1 This course specifically assesses your ability to apply basic geometric principles of conic sections (ellipses, hyperbolas, parabolas) and circles as well as basic vector and matrix algebra to studying two body motion under the influence of mutual gravity. The first key assignment will test these concepts. The weightage of this assignment towards the overall grade is the same as that of one of the other regular assignments.

Key Assignment-2 (Term Paper) An important ingredient of this course is a term paper that involves researching a specific topic (current state-of-the-art in space technology), carry out simulations if needed and submit a report in the last week of November (after the Thanksgiving holiday). The topics for the term papers will be assigned in the first couple of weeks of the class and subsequently. The paper accounts for 10% of the total grade.

Examinations- There will be **three exams**, two of **90 minutes** duration during the course and the **Final Exam**. Make-up examinations will be on a case to case basis and to be eligible for one, there should be a strong reason such as a medical situation. **Sufficient proof** has to be furnished for consideration. You must take the tests at their scheduled times. Each **90 minutes** exam will account for 20% of the total grade while the final exam amounts to 30%. In total, the three exams will form 70% of the grade.

Grading summary:

Assignments	20%
Exam 1	20%
Exam 2	20%
Final Exam	30%
Term Paper	10%
Total	100%

Grade Allocation:

Grading follows the following format.

A	90% and above
B	80% - 89%
C	70% - 79%
D	60% - 69%
F	59% and less

University Policies:

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.

American 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 Disability 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 resets with *informing faculty at the beginning of the semester and in providing authorized documentation through designated administrative channels*. For more information contact the Office of Students with Disabilities at 817-272-3364.

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. All persons involved in academic dishonesty will be disciplined in accordance with University regulations and procedures. Discipline may include suspension or expulsion from the University. "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)

Student Success- The University of Texas at Arlington supports a variety of student success programs to help you connect with the University and achieve academic success. These programs 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.

Inclement Weather Policy- In the event the 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 such closings. You can also get information by dialing (972) 601-2049

Email to Faculty- To contact a faculty member use the email address shown on the top of the syllabus (not the email facility in WebCT). Use as the "subject line": MAE-3304. Put your name inside the email message, start with the main point/question of the message. Emails from outside the UTA domain are subject to be treated as SPAM by the server and deleted.

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 the changes to the syllabus as posted on the class web site.