

EAS 4510 – ASTRODYNAMICS (3 credits) - SPRING 2021

*****THIS CLASS IS ONLINE*****

Syllabus (a.k.a. our contract for the semester)

COURSE INSTRUCTOR: Dr. Riccardo Bevilacqua, bevilr@ufl.edu, 352-392-6230. Office hours: Wednesdays, 10am-12pm.

CLASS WEBSITE: canvas and https://www.youtube.com/channel/UCIhNssruiFKuMf_X2eoEQ?view_as=subscriber for the pre-recorded video lectures (I suggest you watch videos from 2017, I will go in parallel).

CLASS MEETS: M, W, F, period 6 (12:50pm-1:40pm), **ONLINE**. Teaching is a-synchronous, i.e., lectures are pre-recorded and assigned on a weekly basis, while synchronous meetings are to discuss the lectures, answer questions, see examples, and help with Matlab.

TEACHING ASSISTANT/S: Anthony Allen, allen.anthony@ufl.edu, office hours 2-4pm on Monday online (see Canvas Zoom)

PRE-REQUISITES: EGM 3401 (Engineering Mechanics: Dynamics with C or better) and MAP 4305 (Diff Equations for Eng. & Physical Scientists). Working knowledge of at-least one programming language (strongly preferred: MATLAB) is required.

COURSE OBJECTIVES: By the end of this course, you should be able to do the following:

- conceptually understand and distinguish between different types of orbits in space that arise under the laws of gravitational motion,
- understand the causes and consequences of perturbations in space,
- design maneuvers for transferring spacecraft from one orbit to another,
- understand the dynamics of spacecraft rendezvous and proximity operations,
- perform preliminary design of interplanetary missions.

CONTRIBUTION OF COURSE TO MEETING THE PROFESSIONAL COMPONENT (ABET): The table below describes the contribution of this course to development of specific components of professional growth as described in the ABET program criteria. The components have been divided into three streams: aeronautical (ae), astronautical (as) and mechanical (me): There is high coverage for professional components

| Aeronautical | | Astronautical | | Mechanical |
|---|---|---|---|---|
| (ae1) Aerodynamics: | × | (as1) Orbital mechanics: | ✓ | (me1) Apply principles of engineering, basic science & mathematics (inc. multivar. calculus & differential eqns) to model, analyze, design & realize physical systems, components or processes: |
| (ae2) Aerospace materials: | × | (as2) Space environment: | ✓ | |
| (ae3) Structures: | × | (as3) Attitude determination and control: | ✓ | (me2) Work professionally in both thermal and mechanical systems areas: |
| (ae4) Propulsion: | × | (as4) Telecommunications: | × | |
| (ae5) Flight mechanics: | ✓ | (as5) Space structures: | × | × |
| (ae6) Stability and control: | × | (as6) Rocket propulsion: | × | |
| Engineering Design: 20% Mathematics: 30%, Engineering Sciences: 50% | | | | |

(ae5) and (as1). In addition to the program criteria described above, this course will also contribute to the development of proficiency in the subject of numerical methods and the use of computational tools to solve engineering problems.

RELATIONSHIP OF COURSE TO PROGRAM OUTCOMES (ABET): This course will meet several program outcomes as described in the ABET criteria, described in the table below. There will be high coverage for outcomes (a), (c), (e) and (k) in this course. These outcomes will be assessed throughout the semester via homework assignments (to be completed by individual effort) and selected problems on tests. In addition, there is low coverage for outcome (i), which will be assessed through homework.

| Program outcome | Met? | Program outcome | Met? |
|---|------|--|------|
| (a) an ability to apply knowledge of mathematics, science, and engineering | ✓ | (b) an ability to design and conduct experiments, as well as to analyze and interpret data | × |
| (c) an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability | ✓ | (d) an ability to function on multidisciplinary teams | × |
| (e) an ability to identify, formulate, and solve engineering problems | ✓ | (f) an understanding of professional and ethical responsibility | × |
| (g) an ability to communicate effectively | × | (h) the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context | × |
| (i) a recognition of the need for, and an ability to engage in life-long learning | ✓ | (j) a knowledge of contemporary issues | × |
| (k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice. | ✓ | | |

COURSE DESCRIPTION: The table below provides a tentative weekly schedule for this course. Please note that the table is meant only as a guideline and there may be significant variations depending on several factors, e.g. how easily the introductory material is grasped by the class, allowing me to proceed to more advanced topics.

| TOPIC | Week # | Notes |
|--|--------|-----------------------|
| Newtonian particle mechanics, law of gravitation: Chapter 1 | 1-2 | |
| Keplerian motion (two body problem), geometry of conics, integrals of motion, Kepler's laws: Chapter 2 | 3-5 | HW1, Feb. 5, 2021 |
| r v/s t , Kepler's equation and its numerical solution. Orbit in 3D, orbital elements, Euler Angles, ground track: Chapters 3, 4 | 6-8 | Test 1, Feb. 12, 2021 |
| Orbital maneuvers: Hohmann/bielliptic maneuvers, phase/apse/plane change, Non-impulsive maneuvers: Chapter 6 | 9-10 | HW2, Mar. 19, 2021 |
| Orbital perturbations, orbital rendezvous and relative motion: Chapters 12,7 | 11-12 | Test 2, Mar. 26, 2021 |
| Interplanetary trajectories, launch opportunities, patched conics, mid-course corrections, flybys: Chapter 8 | 13-14 | HW3, Apr. 14, 2021 |
| Advanced Topics | 15 | Test 3, Apr. 21, 2021 |

TEXTBOOK/SOFTWARE: Orbital Mechanics for Engineering Students, by Howard D. Curtis, Fourth Edition. Publisher: Elsevier/Butterworth-Heinemann, ISBN: 9780128240250.

You must have access to MATLAB.

HOMEWORK: 3 take-home, 72hr homeworks will be assigned, about 1 week prior to each test. The goal of these homeworks is mainly to prepare you for the test, and in doing so you also gain some points (5% each).

In addition, students are strongly encouraged to solve problems chosen by themselves from the book. Becoming proactive is expected at the Senior level.

TESTS: 3 take home, timed in real time tests, no finals. The tests last 2:45hrs plus 15 minutes for scanning and uploading. I recommend CamScanner as free app to scan and save in pdf. TEST 1: Feb. 12, 2021, 20%. TEST 2, 30%: Mar. 26, 2021, TEST 3: Apr. 21, 2021, 35%. The reason for incremental importance of the test is to allow the students to become incrementally familiar with the topics. The expectations are that students become more and more knowledgeable and capable of solving test problems as the semester progresses.

STK OPTIONAL CERTIFICATIONS: The instructor will provide instructions to access AGI's Systems Tool Kit and to get certified in its use, at the beginning of the semester (<http://agiweb.force.com/faqs/servlet/fileField?id=0BE0a00000007bo>).

Those interested will have the opportunity to receive 10% **bonus** for the first level certification, 20% **bonus** for the second level. **The bonuses are NOT cumulative, i.e. 10% for first level, an additional 10% for second level.** **THIS IS NOT REQUIRED AND COMPLETELY OPTIONAL. IT WILL SERVE WELL THOSE CONTINUING TO SPACECRAFT SENIOR DESIGN.**

THE DEADLINE TO TURN IN PROOF OF CERTIFICATION/S IS APRIL 21, 2021 (DAY OF LAST TEST)

GRADING POLICY: The grading scale is as follows, and it is not flexible:

A: 94 to 100

A-: 90 to 93.99

B+: 85 to 89.99

B: 80 to 84.99

B-: 75 to 79.99

C+: 70 to 74.99

C: 65 to 69.99

C-: 60 to 64.99

D+: 55 to 59.99

D: 50 to 54.99

D-: 45 to 49.99

E: Less Than 45

CLASS ATTENDANCE AND MAKE UP POLICY: Students are expected to attend all lectures although there are no penalties for missing classes: students are responsible for managing their time and learning. Due to large size of the class, there will be no early/late exams. Please make your travel arrangements according to the exam dates specified in the syllabus. The general rule is no make-up exams and no rescheduling of exams to other times.

Requirements for class attendance and make-up exams, assignments, and other work in this course are consistent with university policies that can be found at: <https://catalog.ufl.edu/ugrad/current/regulations/info/attendance.aspx>.

The students remain completely responsible for timely communications with the instructor.

STUDENTS WITH DISABILITIES: Students with disabilities requesting accommodations should first register with the Disability Resource Center (352-392-8565, www.dso.ufl.edu/drc/) by providing appropriate documentation. Once registered, students will receive an accommodation letter which must be presented to the instructor when requesting accommodation. Students with disabilities should follow this procedure as early as possible in the semester. In other words: immediately at the beginning.

CHEATING POLICY: absolutely zero tolerance. Your examinations must be completed completely independently. If anyone is caught having worked together on an exam or having used an unauthorized source, the penalty is an automatic failure of the course.

Cheating breaks the mutual trust between instructor and student. Cheating will invariably result in an automatic "E" grade and the incident will be reported to the University.

UF students are bound by The Honor Pledge which states, "We, the members of the University of Florida community, pledge to hold ourselves and our peers to the highest standards of honor and integrity by abiding by the Honor Code. On all work submitted for credit by students at the University of Florida, the following pledge is either required or implied: "On my honor, I have neither given nor received unauthorized aid in doing this assignment." The Honor Code (<http://www.dso.ufl.edu/sccr/process/student-conduct-honor-code/>) specifies a number of behaviors that are in violation of this code and the possible sanctions. Furthermore, you are obligated to report any condition that facilitates academic misconduct to appropriate personnel. If you have any questions or concerns, please consult with the instructor or TAs in this class.

Students should also familiarize with the Code of Ethics for Engineers: <http://www.nspe.org/resources/ethics/code-ethics>

ONLINE STUDENTS COURSE EVALUATION: Students are expected to provide feedback on the quality of instruction in this course by completing online evaluations at <https://evaluations.ufl.edu>. Evaluations are typically open during the last two or three weeks of

the semester, but students will be given specific times when they are open. Summary results of these assessments are available to students at <https://evaluations.ufl.edu/results/>.

The instructor will also provide a midterm evaluation form to the students, to monitor the development of the class, and make necessary adjustments, when possible. I value your input, and that is why I am giving you an incentive to complete this optional survey at mid-semester. See also grading policy for points assigned to this survey.

CLASS DEMEANOR EXPECTED BY THE INSTRUCTOR: I have little tolerance for students who are repeatedly late to class, cell phone ringing, text messages beeps, and any behavior that may be distracting both students and instructor. Offenders will be asked to leave the classroom, and the lecture will not resume until they comply. If they do not comply, the lecture will be given for granted and the instructor will move on.

Also, I will not be eating while teaching (obviously!), and I expect you not to eat in class.

Contact information for the Counseling and Wellness Center:
<http://www.counseling.ufl.edu/cwc/Default.aspx>, 392-1575; and the **University Police Department:** 392-1111 or 9-1-1 for emergencies