MAE 3145: Orbital Mechanics & Space Dynamics

Fall 2018, W 1810–2040, SEH 3040

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Prerequisites APSC 2058 Analytical Mechanics II

Course Description This course covers the motion of spacecraft under gravity. Included are the derivation and the analyses of the two-body problem and their applications for real world missions. Extensive use of scientific programming languages is required to simulate orbital dynamics and solve real-world astrodynamics problems.

Textbook

- R. Bate, *Fundamentals of Astrodynamics*, Dover Publication, 1971

Contents

- Astrodynamic Fundamentals
  - Time [BMW Chap. 2.9]
  - Coordinate Systems [BMW Chap. 7.4]
  - Project RV2COE [BMW Chap 2.5]
- Orbital Mechanics
  - Dynamics of Point Masses [Curtis Chap. 1]
  - Two-Body Problem [BMW Chap. 1]
  - Orbital Elements [BMW Chap. 2.3]
  - Groundtracks [BMW Chap. 2.15]
  - Project COMFIX [BMW Chap 2.7]
  - Project PROPOGATE [BMW Chap 4]
- Orbital Maneuvers
  - Hohmann Transfers [BMW Chap. 3]
  - Plane Changes [BMW Chap. 3.4]
  - Orbital Rendezvous and Phasing [BMW Chap. 8.3]
- Perturbations [BMW Chap. 8]
  - Geopotential
  - Drag
  - PREDICT
- Extras if we're lucky
  - Method of patched conics
  - Gauss Problem
  - Lambert Problem

Software Projects A major focus of this course will be the application of sound scientific programming skills. You will apply the theoretical tools of astrodynamics to solve realistic problems by implementing your own library of tools.

- RV2COE - convert position and velocity vectors of a spacecraft to classical orbital elements
- COMFIX - determine the orbital elements of a satellite given ground based radar observations
- PROPOGATE - determine the position of a satellite as a function of time
- PREDICT - predict satellite passes for any location on the Earth

Additional Readings - Other sources of useful information

- David A Vallado. *Fundamentals of Astrodynamics and Applications*. 3rd ed. Microcosm Press, 2007
- Richard H Battin. *An Introduction to the Mathematics and Methods of Astrodynamics*. AIAA, 1999
- J. Danby, *Fundamentals of Celestial Mechanics*, Willmann-Bell, 1988
- J. Prussing, *Orbital Mechanics*, Oxford University Press, 1993
- V. Chobotov, *Orbital Mechanics*, AIAA, 2002
- T. Logsdon, *Orbital Mechanics: Theory and Applications*, Wiley, 1997
- Scipy Tutorial: http://www.scipy-lectures.org/

Grading Homework 35%, Attendance 5%, Midterm Exam 20% , Final Exam 20%, Projects 20%

Course Learning Objectives At the end of this course, students will be able to:

1: Explain the Newtonian gravitational force and gravitational potential between particles
2: Analyze the characteristics of circular, elliptic, parabolic and hyperbolic orbits in a two-dimensional plane
3: Describe the geometry of an orbit in a three-dimensional space from orbital elements
4: Apply numerical/analytical techniques to propogate orbits.
5: Choose and apply the approprite orbital maneuvering method to move spacecraft between orbits.
6: Develop personal software tools to solve practical astrodynamic problems:

  - Determine orbital parameters from ground based observations.
  - Predict satellite passes and determine observation angles to view satellites overhead.

Minimum out of class work per week Expect to spend much more time than this.

- Direct Instruction - 2.5 hours
- Indendent Learning - 5 hours

General Policy

1: If you do not have a computer account for accessing Python, you should contact SEAS Computing Facility

2: Class attendance is required. Be punctual and follow the class rules. Students are encouraged to ask questions but talking while the lecture is being delivered is prohibited.

3: If there are any questions regarding grading, you must attach a written explanation of your issue to your assignment and return both to the instructor within one week.

4: Class/Lab cancellation due to weather or special event: Call 202-994-5050 or visit the Campus Advisories Website (`campusadvisories.gwu.edu`) or `www.gwu.edu/~bygeorge/100703/closingpolicy.html` for GW operating status.

5: Disability Support Services (DSS): If a student is to use DSS for testing, he/she should submit the letter from DSS during the first week. Any student who may need an accommodation based on the potential impact of a disability should contact the Disability Support Services office (`http://gwired.gwu.edu/dss/`) during the first week.

6: Students requiring special accommodations for testing through DSS must provide Dr. Kulumani with the appropriate forms or documents and confirm the approval at least two weeks before the test or exam.

Academic Integrity Code Academic dishonesty is defined as cheating of any kind, including misrepresenting one's own work, taking credit for the work of others without crediting them and without appropriate authorization, and the fabrication of information.

All academic integrity violations will be reported in accordance with the GWU code of academic integrity, see: `http://studentconduct.gwu.edu/code-academic-integrity`.

Email Policy

- **Check your GW email account daily**. All of the important announcements of this class will be made through Blackboard/email.
- I will not respond to emails which are composed in an unprofessional manner, or which violates basic email etiquette.
- I do not offer immediate round the clock technical support, please plan ahead accordingly. I will try to respond to emails within 36 hours during the week, and within 72 hours during the weekend.

Homework Policy

- Homework is due at the **beginning of class**.
- **Late homework** assignments **WILL NOT** be accepted **for any reason**.
- Grading of the homework will emphasize your effort to present the solution in a neat and orderly fashion.

Exam Policy

- There is one midterm exam and one final exam.
- **Make-up exams will not be given** . If there are exceptional situations you may discuss with the instructor.