UNSW AUSTRALIA

Course Outline

Semester 1, 2015

Never Stand Still | Faculty of Engineering | School of Mechanical and Manufacturing Engineering

AERO9500

SPACE SYSTEMS ARCHITECTURES AND ORBITS

Contents

Course Outline

AERO9500 Space Systems Architectures and Orbits

1. COURSE STAFF

Contact details and consultation times for course convener

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Questions regarding course content should be directed to the course Moodle forum. Consultation concerning this course is primarily by email. If you would like to meet please email to schedule a meeting time. Minor matters can be discussed after class.

Contact details and consultation times for additional lecturers and laboratory teaching staff

Dr Alex von Brasch (space segment, ground segment & systems eng.)
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2. COURSE DETAILS

Units of credit

This is a 6 unit-of-credit (UoC) course, and involves 6 hours per week (h/w) of face-to-face contact.

The UNSW website states “The normal workload expectations of a student are approximately 25 hours per semester for each UoC, including class contact hours, other learning activities, preparation and time spent on all assessable work.”

For a standard 24 UoC in the semester, this means 600 hours, spread over an effective 15 weeks of the semester (thirteen weeks plus stuvac plus one effective exam week), or 40 hours per week, for an average student aiming for a credit grade. Various factors, such as your own ability, your target grade, etc., will influence the time needed in your case.

Some students spend much more than 40 h/w, but you should aim for not less than 40 h/w on coursework for 24 UoC.

This means that you should aim to spend not less than about 10 h/w on this course, i.e. an additional 4 h/w of your own time. This should be spent in making sure that you understand the lecture material, completing the set assignments, further reading about the course material, and revising and learning for the examination.

Summary of the course

This course gives an overview of satellite systems from the space segment to the ground segment, describing the main applications of satellite systems, as well as providing a detailed introduction into the principles of orbital mechanics.

Aims of the course

The course is divided into two major parts: the first part will paint the overall picture of a satellite system, setting it in the wider context of space, describing its major components and central concepts, to provide students with a solid introduction to satellite systems and the associated technologies. The second part of the course focuses on the details of orbital mechanics, covering orbit description and analysis, orbital perturbations, orbital manoeuvres, and satellite launches.

Student learning outcomes

At the conclusion of this course, it is expected that you will be able to:

- explain the main applications of satellites and the way affect our everyday lives.
- describe the overall system design of a satellite and its supporting earth stations, and be able to cite the major functional subsystems of a satellite along with the principles of operation of each, and the associated overall design aspects.
- have a basic understanding of space mission design and analysis.
- understand basic spacecraft orbital principles, such as how satellites acquire orbits, maintain orbits, the key parameters used to describe an orbit, and commonly employed satellite orbits.

- apply fundamental principles in the analysis of basic orbital mechanics problems
- describe and plan basic orbital manoeuvring techniques, such as impulse manoeuvres, Hohmann transfers, orbital plane changes and rendezvoux
- explain the basic principles of satellite launch mechanics.
- Use Systems Toolkit (STK) to design and analyse basic space missions.

Graduate attributes

UNSW's graduate attributes are shown at https://my.unsw.edu.au/student/atoz/GraduateAttributes.html

UNSW aspires to develop graduates who are rigorous scholars, capable of leadership and professional practice in a global community. The university has, thus, articulated the following Graduate Attributes as desired learning outcomes for ALL UNSW students.

UNSW graduates will be

1. Scholars who are:
   - (a) understanding of their discipline in its interdisciplinary context ✓
   - (b) capable of independent and collaborative enquiry ✓
   - (c) rigorous in their analysis, critique, and reflection ✓
   - (d) able to apply their knowledge and skills to solving problems ✓
   - (e) ethical practitioners
   - (f) capable of effective communication ✓
   - (g) information literate ✓
   - (h) digitally literate ✓

2. Leaders who are:
   - (a) enterprising, innovative and creative ✓
   - (b) capable of initiating as well as embracing change
   - (c) collaborative team workers ✓

3. Professionals who are:
   - (a) capable of independent, self-directed practice ✓
   - (b) capable of lifelong learning
   - (c) capable of operating within an agreed Code of Practice

4. Global Citizens who are:
   - (a) capable of applying their discipline in local, national and international contexts ✓

(b) culturally aware and capable of respecting diversity and acting in socially just/responsible ways
(c) capable of environmental responsibility

✓ = Developed in this course

3. RATIONALE FOR INCLUSION OF CONTENT AND TEACHING APPROACH

This is one of the core courses for the ELECSS (Satellite Systems Engineering) stream of the 8539 Masters of Engineering Science (Extension) program. The course is also available as a 4th year technical elective within a Bachelor of Engineering.

Pre-requisites: Completion of the third stage of a bachelor of engineering from a related discipline (Electrical, Mechanical, Aerospace, Surveying, Computer Science) or equivalent.

Assumed Knowledge: It is assumed that students understand the principles of mechanics, as would be obtained from an above average completion of elementary physics courses at an institution such as UNSW. In addition, it is assumed that students have a solid grounding in tertiary level mathematics, including differential equations and matrix algebra.

Following Courses: It is intended (though not required) that this be taken early in the Satellite Systems Engineering Masters program, as it will cover many of the underlying concepts and terminology required for the specialist courses, as well as place these courses in the wider context of the satellite system.

Effective learning is supported when you are actively engaged in the learning process and by a climate of enquiry, and these are both an integral part of the lectures and labs. Dialogue is encouraged between you, others in the class and the lecturer. Diversity of experiences is acknowledged, as some students in each class have prior experience. Your experiences are drawn on to illustrate various aspects, and this helps to increase motivation and engagement.

4. TEACHING STRATEGIES

Lectures in the course are designed to cover the terminology and core concepts and theories. The lectures are intended as a foundation for further investigation. The fundamental principles of and the specific system implementation cases will be illustrated with examples and simulations. The lecture slides will take a different perspective from the written notes, and both the lecture notes and lecture overheads together constitute examinable material. This course will be delivered by lectures, nominally three hours per week. Students are expected to prepare for lectures in advance by reading the appropriate sections of the textbook prior to the lesson.

Worked tutorial-type questions will be presented in the course of the lecture program, to expose students to the techniques involved in solving exam-style questions in this topic. There will be no formal tutorial classes scheduled, however the solutions to certain tutorial questions will be presented in the lecture classes, at the lecturer's discretion. A list of suggested problems and their answers (though not worked-out full solutions) will be posted for each topic. It is highly recommended that you make use of these problem sets and make sure you understand how to solve them.

Laboratories: There will be laboratories scheduled throughout the session. The laboratory exercises consist of simulation scenarios performed using the Systems Toolkit (STK) software. These laboratory exercises aim to illustrate the main concepts taught in the lectures and covered by the tutorial problems and to provide a further means of understanding the material. STK is industry-standard software for space mission design and analysis. The STK labs will be in the Tyree building, in rooms G16/G17 on Friday afternoons staring from week 7.

5. ASSESSMENT

General

You will be assessed by way of two assignments, a quiz, and a final exam, all of which involve calculations and descriptive material. These contribute towards the overall grade as follows:

Task	Learning Outcomes	Graduate Attributes	Mark	Weight	Date
Mid-Semester Quiz	1, 2, 3, 4	1b, 1c, 1d, 1f, 2a, 3a, 3c	10	10%	Week 6
Mission Design Assignment 1	1, 2, 3, 4	1a, 1b, 1c, 1d, 1f, 1g, 1h, 2a, 3a, 3c, 4a	20	20%	Week 6
Mission Design Assignment 2	1, 2, 3, 4	1a, 1b, 1c, 1d, 1f, 1g, 1h, 2a, 3a, 3c, 4a	20	20%	Week 13
Final Exam	1, 2, 3, 4, 5, 6	1b, 1c, 1d, 1f, 2a, 3a, 3c	50	50%	Exam period
Total			100	100%	

In order to pass the course, you must achieve an overall mark of at least 50%.

Assignments

In the assignments you will be required to provide a preliminary design for a space mission and present your work in a technical engineering report. You will have to provide background information based on research of similar past and proposed space missions, outline the rationale and design approach you have chosen for your mission, support your decision with appropriate calculations, and discuss the implications and feasibility of your proposed design. The two assignments will draw on the material learned in the two main sections of the course respectively.

Presentation

A standard specification is available from the School office to aid presentation of your assignments (in all courses). All submissions should have a standard School cover sheet. All submissions are expected to be neat and clearly set out. All calculations should be shown as, in the event of incorrect answers, marks are awarded for method and understanding.

The preferred set-out of any numerical calculation is similar to the following:

$\Delta = \rho\nabla$	(Equation in symbols)
$\Delta = 1.025 \times 200$	(Numbers substituted)
$\Delta = 205$ t	(Answer with units)

Marking Criteria

The following criteria will be used to grade the assignment:

- Identification of key facts and the integration of those facts in a logical development.
- Clarity of communication—this includes development of a clear and orderly structure and the highlighting of core arguments.
- Sentences in clear and plain English—this includes correct grammar, spelling and punctuation.
- Correct referencing in accordance with the prescribed citation and style guide.
- Accuracy of numerical answers.
- All working shown.
- Use of diagrams, where appropriate, to support or illustrate the calculations.
- Use of graphs, were appropriate, to support or illustrate the calculations.
- Use of tables, where appropriate, to support or shorten the calculations.

Submission

The assignments will be available on the Moodle course website and submission is electronic via Moodle. Late submission of assignments attracts a penalty of ten percent per *day*, unless prior dispensation has been given; i.e. see me **before** the due date to avoid penalty.

Mid-semester Quiz

There will be a short test held in Week 6 covering topics covered in the lectures from Weeks 1 to 5.

Final Exam

The final exam will be three hours in duration, covering all topics in the course, held during the end-of-semester exam period. It accounts for 50% of the available course grade.

You will need to provide your own calculator, of a make and model approved by UNSW, for the examinations. The list of approved calculators is shown at: https://student.unsw.edu.au/exam-approved-calculators-and-computers

It is your responsibility to ensure that your calculator is of an approved make and model, and to obtain an “Approved” sticker for it from the School Office or the Engineering Student Centre prior to the examination. Calculators not bearing an “Approved” sticker will not be allowed into the examination room.

Special Consideration and Supplementary Assessment

For details of applying for special consideration and conditions for the award of supplementary assessment, see *Administrative Matters for All Courses*, available from the School website.

6. ACADEMIC HONESTY AND PLAGIARISM

Plagiarism is using the words or ideas of others and presenting them as your own. Plagiarism is a type of intellectual theft. It can take many forms, from deliberate cheating to accidentally copying from a source without acknowledgement. UNSW has produced a booklet which provides essential information for avoiding plagiarism: https://my.unsw.edu.au/student/academiclife/Plagiarism.pdf

There is a range of resources to support students to avoid plagiarism. The Learning Centre assists students with understanding academic integrity and how not to plagiarise. They also hold workshops and can help students one-on-one. Information is available on the dedicated website Plagiarism and Academic Integrity website: http://www.lc.unsw.edu.au/plagiarism/index.html

You are also reminded that careful time management is an important part of study and one of the identified causes of plagiarism is poor time management. Students should allow sufficient time for research, drafting and the proper referencing of sources in preparing all assessment tasks.

If plagiarism is found in your work when you are in first year, your lecturer will offer you assistance to improve your academic skills. They may ask you to look at some online resources, attend the Learning Centre, or sometimes resubmit your work with the problem fixed. However more serious instances in first year, such as stealing another student's work or paying someone to do your work, may be investigated under the Student Misconduct Procedures.

Repeated plagiarism (even in first year), plagiarism after first year, or serious instances, may also be investigated under the Student Misconduct Procedures. The penalties under the procedures can include a reduction in marks, failing a course or for the most serious matters (like plagiarism in a honours thesis) even suspension from the university. The Student Misconduct Procedures are available here: http://www.gs.unsw.edu.au/policy/documents/studentmisconductprocedures.pdf

Further information on School policy and procedures in the event of plagiarism is presented in a School handout, *Administrative Matters*, available on the School website.

7. COURSE SCHEDULE

Week	Date	Topics	Lecturer	Reading	Misc.
1	Mar 6	Course introduction Elements of a space mission Satellite applications	NT	CH. 1	
2	Mar 13	Space Mission Design Space System Architectures Principles of space systems engineering	AVB	1.2	
3	Mar 20	Space Segment Design and Operation	AVB	Notes will be provided	
4	Mar 27	Ground Segment Design and Operation	AVB	Notes will be provided	
5	Apr 3	PUBLIC HOLIDAY no class			
Mid-semester break					
6	Apr 17	Historical overview of astrodynamics Kepler's Laws Orbit geometry	NT	2.1 Ch 3 intro 3.1	Quiz Assignment 1 due
7	Apr 24	2 body problem Conic sections Orbit equation Constants of orbital motion Coordinate systems	NT	Ch 3.1 – 3.15 3.1.7	Intro to STK
8	May 1	Classic orbital elements Alternate orbital elements Orbit types Time	NT	3.1.8 3.4, 3.4.1, 3.4.1.1 3.4.2 3.4.3 3.1.6 – 3.1.6.4	STK lab
9	May 8	Hohmann transfers Plane changes Rendezvous	NT	3.2	STK lab
10	May 15	Ground tracks Orbital perturbations: effects and modelling	NT	3.3.3 3.3.2	STK lab
11	May 22	Interplanetary travel Patched-conic approximation Gravity assist trajectories	NT	3.5 – 3.5.4.4 3.5.9 3.1.5.1	STK lab
12	May 29	Launch sites Launch SEZ Rocket equation	NT	3.3.1 3.4.1.2 -3.4.1.5 3.4.3.1, 3.4.3.2	STK lab
13	Jun 5	Revision and overflow	NT		Assignment 2 due

The schedule may be subject to change at short notice to suit exigencies. Make sure to keep updated of changes, announced in class and on Moodle.

8. RESOURCES FOR STUDENTS

Textbook

There is a **required** textbook for this course which is available as an e-book via the UNSW library:

- *Elements of Spacecraft Design*, C. Brown

The relevant chapters are shown in the course schedule and will also be posted on Moodle. It is expected that students read the relevant chapters prior to the lecture and refer to them when studying.

Suggested additional readings

There are also a number of recommended books that a closely related to course content. Many of these books are available through the library.

- *Astronautics*, second edition, U. Walter.
- *Spacecraft Systems Engineering*, fourth edition, P. Fortescue, G. Swinerd and J. Stark
- *Introduction to Flight,* seventh edition, J. D. Anderson Jr (chapters 8 and 9).
- *Orbital Mechanics for Engineering Students*, second edition, H. Curtis.
- *Fundamentals of Astrodynamics,* R. R. Bate, D. D. Mueller and J. E. White

Additional materials provided in Moodle

This course has a website on Moodle which includes:

- lecture notes
- handouts
- recommended problem sets
- a discussion forum

The discussion forum is intended for you to use with other students enrolled in this course. The course convenor will occasionally look at the forum, monitor the language used and take note of any frequently-asked questions, and may respond to questions on the forum if needed.

Recommended Internet sites

There are many websites giving extra study material for this course:

- AGI http://www.agi.com
- Aviation Week and Space Technology, http://www.aviationweek.com/aw/
- NASA http://www.nasa.gov
- UNSW Library http://www.library.unsw.edu.au/

More websites will be identified in the lectures and on Moodle.

Other Resources

If you wish to explore any of the lecture topics in more depth, then other resources are available and assistance may be obtained from the UNSW Library.

One starting point for assistance is:
www.library.unsw.edu.au/servicesfor/students.html

9. COURSE EVALUATION AND DEVELOPMENT

Feedback on the course is gathered periodically using various means, including the Course and Teaching Evaluation and Improvement (CATEI) process, informal discussion in the final class for the course, and the School's Student/Staff meetings. Your feedback is taken seriously, and continual improvements are made to the course based, in part, on such feedback.

10. ADMINISTRATIVE MATTERS

You are expected to have read and be familiar with Administrative Matters, available on the School website. This document contains important information on student responsibilities and support, including special consideration, assessment, health and safety, and student equity and diversity.

N. Tsafnat
20 February 2015