UNSW AUSTRALIA

Course outline

Semester 1 2017

Never Stand Still | Engineering | Mechanical and Manufacturing Engineering

AERO9500
Space Systems Architectures and Orbits

Contents

1. Staff contact details

Contact details and consultation times for course convenor

Name: Naomi Tsafnat
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Consultation by email.

Contact details and consultation times for additional lecturers/demonstrators/lab staff

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Consultation by appointment via email.

2. Course details

Credit Points

This is a 6 unit-of-credit (UoC) course, and involves 4 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. Thus, for a full-time enrolled student, the normal workload, averaged across the 16 weeks of teaching, study and examination periods, is about 37.5 hours per week.”

This means that you should aim to spend about 9 h/w on this course. The additional time should be spent in making sure that you understand the lecture material, completing the set assignments, further reading, and revising for any examinations.

Contact hours

	Day	Time	Location
Lectures	Tuesday	5pm – 6:30pm	Ainsworth 102
	Wednesday	5pm – 6:30pm	Old Main Building 150
Demonstrations	Wednesday	6:30pm – 7:30pm	Ainsworth 204

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. 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 and 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, interplanetary transfers and launch systems.

Aims of the course

The course aims to provide the student with an in-depth understanding of spacecraft operations in terms of their orbits and trajectories, manoeuvres and launch. This course is both a 4th year undergraduate elective and a core component of the Space Systems Engineering Masters course, and as such it will provide a detailed overview of the space segment, allowing the students to apply their skills to analysis of space systems and the design of space missions.

Student learning outcomes

This course is designed to address the learning outcomes below and the corresponding Engineers Australia Stage 1 Competency Standards for Professional Engineers as shown. The full list of Stage 1 Competency Standards may be found in Appendix A.

After successfully completing this course, you should be able to:

Learning outcome		**EA Stage 1 Competencies**
1.	Explain the main applications of satellites and the way affect our everyday lives.	1.1, 1.3
2.	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.	1.3, 1.5

3.	Analyse spacecraft orbits and their perturbations, and recognise commonly employed satellite orbits.	1.3, 2.1
4.	Compute delta-V and fuel requirements for various orbital manoeuvres, interplanetary transfers, and launches.	1.3, 2.1
5.	Simulate and design space missions using Systems Toolkit (STK).	2.3, 3.2

3. 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 Systems Toolkit (STK). 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. Labs will be at the Ainsworth building computer lab (room 204) starting Week 7, on Wednesdays after the lecture, 18:30 – 19:30.

4. Course schedule

Date	Topic	Location	Lecture Content	Lab Content	Suggested Reading
Wk 1 28/2	Course introduction	102	Administrative matters Space technologies Elements of a space mission		Ch. 1
1/3		OMB 150	Satellite applications, examples of current/past missions		
Wk 2 7/3	Space systems architectures	102	Space mission design Space system architectures		(AVB notes)
8/3		OMB 150	Principles of space systems engineering		
Wk 3 14/3	The space segment	102	Space Mission Design Space System Architectures		(AVB notes)
15/3		OMB 150	Principles of space systems engineering		
Wk 4 21/3	The ground segment	102	Ground Segment Design and Operation		(AVB notes)
22/3		OMB 150	Ground Segment Design and Operation (cont.)		
Wk 5 28/3	Orbits	102	**Quiz** Covering weeks 1 - 4		
29/3		OMB 150	Historical overview of astrodynamics Kepler's Laws Orbit geometry and nomenclature		2.1 Ch. 3 (intro) 3.1
Wk 6 4/4	Orbit equation	102	Conic sections Constants of orbital motion 2 body problem		3.1 – 3.15 3.1.7
5/4		OMB 150	Orbit equation Coordinate systems Lagrange points		
Wk 7 11/4	Orbit elements	102	Classic Orbit Elements (COE)		3.1.8 3.4, 3.4.1, 3.4.1.1 3.4.2 3.4.3 3.1.6 –
12/4		OMB 150	Alternate orbit elements (AOE) Orbit types Sidereal time	Intro to STK COE	

					3.1.6.4
Mid-Semester Break					
Wk 8 25/4	Orbit perturbations		ANZAC Day Holiday		3.3.3
26/4		OMB 150	Ground tracks	Ground tracks	
Wk 9 2/5	Impulse Orbit Manoeuvres	102	Hohmann transfers Simple plane changes		3.2 - 3.2.4 3.4.1.3 3.4.1.4
3/5		OMB 150	Combined plane changes Rendezvous	Manoeuvres	
Wk 10 9/5	Propulsion	102	Orbit Perturbations		3.3.2 4.1 4.2 4.3.1 4.3.2
10/5		OMB 150	Launch vehicles Rocket equation	Perturbations	
Wk 11 16/5	Launch	102	Launch sites Launch SEZ		3.3.1 3.4.1.2 -- 3.4.1.5 3.4.3.1 3.4.3.2
17/5		OMB 150	Launch SEZ (cont.)	Launch	
Wk 12 23/5	Interplanetary transfers	102	Interplanetary travel Patched-conics method		3.5 – 3.5.4.4 3.5.9 3.1.5.1
24/5		OMB 150	Patched conics (cont.) Gravity assist trajectories	Interplanetary transfers	
Wk 13 30/5	Revision	102			

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

5. Assessment

Assessment overview

Assessment	Length	Weight	Learning outcomes assessed	Assessment criteria	Due date and submission requirements	Deadline for absolute fail	Marks returned
Assignment	10 pages	20%	1,2	Topics assessed include understanding of space mission design, ability to critically analyse a mission, report writing skills	Electronic submission on Moodle, by Week 8, 25/4/16 at midnight	29/4 at midnight	Two weeks after submission
Quiz	1.5 hour	18%	1,2,3	Lecture material from weeks 1-4.	Week 5, in class	N/A	Two weeks after submission
STK tutorials	Six short tutorial assign ment	12% (2% each)	5	Demonstration of proper use of STK	During weeks 7-12 demonstration classes	24 hours after start of lab	One week after submission
Final exam	2 hours	50%	1,2,3,4	All course content from weeks 1-12 inclusive.	Exam period, date TBC	N/A	Upon release of final results

Assignments

For the **Assignment**, 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 present 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.

A **Quiz** will be conducted in-class in Week 5 and cover the material from weeks 1-4 as advised above. The quiz will be up to 1.5 hours in duration and will include several questions to assess your understanding of the material. The quiz will be marked and returned within two weeks.

STK tutorial assignments will be conducted during the lab on Wednesdays and are due by the end of the lab session. These will be marked and returned in the next week.

Presentation

All submissions are expected to be neat and clearly set out. Your results are the pinnacle of all your hard work and should be treated with due respect. Presenting results clearly gives the marker the best chance of understanding your method; even if the numerical results are incorrect.

Submission

Late submissions will be penalised 5 marks per calendar day (including weekends). An extension may only be granted in exceptional circumstances. Where an assessment task is worth less than 20% of the total course mark and you have a compelling reason for being unable to submit your work on time, you must seek approval for an extension from the course convenor ***before the due date***. Special consideration for assessment tasks of 20% or greater must be processed through student.unsw.edu.au/special-consideration.

It is always worth submitting late assessment tasks when possible. Completion of the work, even late, may be taken into account in cases of special consideration.

Where there is no special consideration granted, the 'deadline for absolute fail' in the table above indicates the time after which a submitted assignment will not be marked, and will achieve a score of zero for the purpose of determining overall grade in the course.

Marking

Marking guidelines for assignment submissions will be provided at the same time as assignment details to assist with meeting assessable requirements. Submissions will be marked according to the marking guidelines provided.

Examinations

You must be available for all tests and examinations. Final examinations for each course are held during the University examination periods, which are June for Semester 1 and November for Semester 2.

Provisional Examination timetables are generally published on myUNSW in May for Semester 1 and September for Semester 2

For further information on exams, please see the Exams section on the intranet.

Calculators

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 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 the School intranet, and the information on UNSW’s Special Consideration page.

6. Expected resources for students

Textbook

There is a **required** textbook for this course which is available as an e-book via the UNSW library https://www.library.unsw.edu.au/:

- *Elements of Spacecraft Design*, C. Brown

The relevant chapters are shown in the course schedule and will also be posted on Moodle. A few printed copies are also available in the library. 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 are 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

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

7. Course evaluation and development

Feedback on the course is gathered periodically using various means, including the UNSW myExperience 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.

In this course, recent improvements resulting from student feedback include changes to the assessment structure, inclusion of more diverse assessment criteria to provide more feedback to students, inclusion of more worked out tutorial problems, and changes to the STK lab tutorials.

8. Academic honesty and plagiarism

UNSW has an ongoing commitment to fostering a culture of learning informed by academic integrity. All UNSW students have a responsibility to adhere to this principle of academic integrity. Plagiarism undermines academic integrity and is not tolerated at UNSW. *Plagiarism at UNSW is defined as using the words or ideas of others and passing them off 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 website with a wealth of resources to support students to understand and avoid plagiarism: student.unsw.edu.au/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.

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 an honours thesis) even suspension from the university. The Student Misconduct Procedures are available here:
www.gs.unsw.edu.au/policy/documents/studentmisconductprocedures.pdf

Further information on School policy and procedures in the event of plagiarism is available on the intranet.

9. Administrative matters

All students are expected to read and be familiar with School guidelines and polices, available on the intranet. In particular, students should be familiar with the following:

- Attendance, Participation and Class Etiquette
- UNSW Email Address
- Computing Facilities
- Assessment Matters (including guidelines for assignments, exams and special consideration)
- Academic Honesty and Plagiarism
- Student Equity and Disabilities Unit
- Health and Safety
- Student Support Services

Naomi Tsafnat
2/2/2017

Appendix A: Engineers Australia (EA) Competencies

Stage 1 Competencies for Professional Engineers

	Program Intended Learning Outcomes
PE1: Knowledge and Skill Base	PE1.1 Comprehensive, theory-based understanding of underpinning fundamentals
	PE1.2 Conceptual understanding of underpinning maths, analysis, statistics, computing
	PE1.3 In-depth understanding of specialist bodies of knowledge
	PE1.4 Discernment of knowledge development and research directions
	PE1.5 Knowledge of engineering design practice
	PE1.6 Understanding of scope, principles, norms, accountabilities of sustainable engineering practice
PE2: Engineering Application Ability	PE2.1 Application of established engineering methods to complex problem solving
	PE2.2 Fluent application of engineering techniques, tools and resources
	PE2.3 Application of systematic engineering synthesis and design processes
	PE2.4 Application of systematic approaches to the conduct and management of engineering projects
PE3: Professional and Personal Attributes	PE3.1 Ethical conduct and professional accountability
	PE3.2 Effective oral and written communication (professional and lay domains)
	PE3.3 Creative, innovative and pro-active demeanour
	PE3.4 Professional use and management of information
	PE3.5 Orderly management of self, and professional conduct
	PE3.6 Effective team membership and team leadership