



Mechanical and Manufacturing Engineering

Course Outline

Semester 1 2018

AERO9500 SPACE SYSTEMS ARCHITECTURES AND ORBITS

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1. Staff contact details

Contact details and consultation times for course convenor

Name: Naomi Tsafnat

Email: n.tsafnat@unsw.edu.au

Moodle: <https://moodle.telt.unsw.edu.au/login/index.php>

Consultation will be primarily by email.

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

Dr Alex von Brasch

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Scott Dorrington (demonstrator, STK lab)

Email: s.dorrington@unsw.edu.au

Consultation by appointment via email

Please see the course [Moodle](#).

2. Important links

- [Moodle](#)
- [UNSW Mechanical and Manufacturing Engineering](#)
- [Course Outlines](#)
- [Student intranet](#)
- [UNSW Mechanical and Manufacturing Engineering Facebook](#)
- [UNSW Handbook](#)

3. 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 | Monday | 2:30 – 4:00pm | Macauley Theatre (E15) |
| | Tuesday | 3:30 – 5:00pm | Ainsworth 202 (J17) |
| | | | |
| Demonstrations | Tuesday (starting week 7) | 5:00pm – 6:00pm | Ainsworth 204 (J17) |

Please refer to your class timetable for the learning activities you are enrolled in and attend only those classes.

Summary and Aims 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.

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

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 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 Tuesdays after the lecture, 17:00 – 18:00. The software is available for you to use at any other time to complement your learning.

5. Course schedule

| Date | Topic | Location | Lecture Content | Lab Content | Suggested Reading |
|---------------------|-----------------------------|----------|---|-------------|-------------------|
| Wk 1 26/2 | Course introduction | E15 1027 | Administrative matters Space technologies Elements of a space mission | | Ch. 1 |
| 27/2 | | 202 | Satellite applications, examples of current/past missions | | |
| Wk 2 5/3 | Space systems architectures | E15 1027 | Space mission design Space system architectures | | (AVB notes) |
| 6/3 | | 202 | Principles of space systems engineering | | |

| Date | Topic | Location | Lecture Content | Lab Content | Suggested Reading |
|---------------------|------------------------------|----------|--|---------------------|--|
| Wk 3 12/3 | The space segment | E15 1027 | Space Mission Design Space System Architectures | | (AVB notes) |
| 13/3 | | 202 | Principles of space systems engineering | | |
| Wk 4 19/3 | The ground segment | E15 1027 | Ground Segment Design and Operation | | (AVB notes) |
| 20/3 | | 202 | Ground Segment Design and Operation (cont.) | | |
| Wk 5 26/3 | Orbits | E15 1027 | Quiz 1 Covering weeks 1 - 4 | | |
| 27/3 | | 202 | Historical overview of astrodynamics Kepler's Laws Orbit geometry and nomenclature | | 2.1 Ch. 3 (intro) 3.1 |
| | | | Mid-Semester Break | | |
| Wk 6 9/4 | Orbit equation | E15 1027 | Conic sections Constants of orbital motion 2 body problem | | 3.1 – 3.15 3.1.7 3.1.8 |
| 10/4 | | 202 | Orbit equation Coordinate systems Lagrange points | | |
| Wk 7 16/4 | Orbit elements | E15 1027 | Classic Orbit Elements (COE) | | 3.4, 3.4.1, 3.4.1.1 3.4.2 3.4.3 3.1.6 – 3.1.6.4 |
| 17/4 | | 202 | Alternate orbit elements (AOE) Orbit types Sidereal time | Intro to STK COE | |
| Wk 8 23/4 | Impulse Orbit Manoeuvres | E15 1027 | Hohmann transfers Simple plane changes | | 3.2 - 3.2.4 3.4.1.3 3.4.1.4 |
| 24/4 | | 202 | Combined plane changes Rendezvous | Manoeuvres | |
| Wk 9 30/5 | Ground tracks, perturbations | E15 1027 | Ground tracks | | 3.3.2 3.3.3 |
| 1/5 | | 202 | Orbit Perturbations | Ground tracks | |
| Wk 10 7/5 | Propulsion | E15 1027 | Quiz 2 Covering weeks 5-9 | | 4.1 4.2 4.3.1 4.3.2 |
| 8/5 | | 202 | Launch vehicles Rocket equation | Perturbations | |

| Date | Topic | Location | Lecture Content | Lab Content | Suggested Reading |
|----------------------|--------------------------|-----------------|---|--------------------------|-----------------------------------|
| Wk 11 14/5 | Launch | E15 1027 | Launch sites Launch SEZ | | 3.3.1 3.4.1.2 --3.4.1.5 |
| 15/5 | | 202 | Launch SEZ (cont.) | Launch | 3.4.3.1 3.4.3.2 |
| Wk 12 21/5 | Interplanetary transfers | E15 1027 | Interplanetary travel Patched-conics method | | 3.5 – 3.5.4.4 3.5.9 3.1.5.1 |
| 22/5 | | 202 | Patched conics (cont.) Gravity assist trajectories | Interplanetary transfers | |
| Wk 13 28/5 | Revision | E15 1027 | Review topics as requested by students | | |

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

6. 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 | 15% | 1 | 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 (2) | 1.5 hour each | 28% (14% each) | 1,2 | Lecture material from weeks 1-4; Lecture material from weeks 5-9 | Week 5, 26/3/18, in class; Week 10, 7/5/18, in class | N/A | Two weeks after submission |
| STK tutorials | Six short tutorial assignments | 12% (2% each) | 4 | 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 | 45% | 1,2,3 | 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.

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

Presentation

All non-electric submissions should have a standard School cover sheet which is available from this course's Moodle page.

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. Special consideration for assessment tasks 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

Quiz 1 will be conducted in-class in Week 5 and cover the material from weeks 1-4. 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.

Quiz 2 will be conducted in-class in Week 10 and cover the material from weeks 5-9. 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.

The **final exam** will cover all course material and will be open book and open notes (in paper form only).

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](#).

7. Attendance

You are required to attend a minimum of 80% of all classes, including lectures, labs and seminars. It is possible to fail the course if your total absences equal to more than 20% of the required attendance. Please see the [School intranet](#) and the [UNSW attendance page](#) for more information.

8. Expected resources for students

Textbook

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

- *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.

UNSW Library website: <https://www.library.unsw.edu.au/>

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.

Moodle: <https://moodle.telt.unsw.edu.au/login/index.php>

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>

9. 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.

10. 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](#).

11. Administrative matters and links

All students are expected to read and be familiar with School guidelines and policies, 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](#)

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 |