UNSW Course Outline

ELEC9725 Satellite Navigation: Systems, Signals & Receivers - 2024

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General Course Information

Course Code : ELEC9725
Year : 2024
Term : Term 1
Teaching Period : T1
Is a multi-term course? : No
Faculty : Faculty of Engineering
Academic Unit : School of Electrical Engineering & Telecommunications
Delivery Mode : In Person
Delivery Format : Standard
Delivery Location : Kensington
Campus : Sydney
Study Level : Postgraduate
Units of Credit : 6

Useful Links

Handbook Class Timetable

Course Details & Outcomes

Course Description

This course introduces the electronic and signal processing aspects of Global Positioning

System (GPS) and other satellite navigation systems such as Galileo, GLONASS, and Beidou. The following topics are covered in the course: signal specifications, introduction to CDMA, frequency plan implications of the new GNSS signals, calculating a position, problems receiver designers must overcome (multipath, interference etc.), front-end RF design, correlator principles and approaches, signal acquisition/reacquisition, how measurements are made, receiver interfaces, augmentation systems (e.g. EGNOS, WAAS), Software Radio, weak signal and Assisted GPS and Interference. These principles will be illustrated using Matlab, allowing students to develop algorithm components of receivers.

Course Aims

The course aims firstly to introduce the principles of satellite navigation, as it is expected that students will have no familiarity these principles. Once that is established, it becomes possible to look at the key problems with the systems that have kept people active and interested in working in this area for the past 50 years. Students should be able to engage with these problems, and see where they affect the current state of satellite navigation.

The lectures cover a lot of material, so students will have a strong basis on which to build, and the assignments provide some practical experience, so if ever an engineer encounters an application of GNSS or a requirement to integrate it into a product, this course should give that engineer a good understanding of how to meet that requirement.

Relationship to Other Courses

This is a postgraduate course in the School of Electrical Engineering and Telecommunications, available to selected undergraduates. It is an elective in several MSc programs.

Course Learning Outcomes

Course Learning Outcomes
CLO1 : Explain how satellite navigation systems work and how they interact with each other
CLO2 : Explain the workings of a satellite navigation receiver in terms of the signal design and why it has that design, and receiver subsystems and their functions in processing those signals
CLO3 : Select appropriate subsystems (e.g. antenna, RF front end) for a GPS receiver design
CLO4 : Make sound decisions about a GPS solution for integration within a larger system, based on your knowledge of how GPS components affect performance,
CLO5 : Make an educated selection of GNSS receiver from those receiving GPS, Glonass, WAAS, Galileo, QZSS signals on the L1, L2, L5, E5 and E6 frequencies.

Course Learning Outcomes	Assessment Item
CLO1 : Explain how satellite navigation systems work and how they interact with each other	• Final Quiz • In-class quizzes • Assignments
CLO2 : Explain the workings of a satellite navigation receiver in terms of the signal design and why it has that design, and receiver subsystems and their functions in processing those signals	• Final Quiz • In-class quizzes • Assignments
CLO3 : Select appropriate subsystems (e.g. antenna, RF front end) for a GPS receiver design	• Final Quiz • In-class quizzes • Assignments
CLO4 : Make sound decisions about a GPS solution for integration within a larger system, based on your knowledge of how GPS components affect performance,	• Final Quiz • In-class quizzes • Assignments
CLO5 : Make an educated selection of GNSS receiver from those receiving GPS, Glonass, WAAS, Galileo, QZSS signals on the L1, L2, L5, E5 and E6 frequencies.	• Final Quiz • In-class quizzes • Assignments

Learning and Teaching Technologies

Moodle - Learning Management System

Learning and Teaching in this course

Delivery Mode

The teaching in this course aims at establishing a good fundamental understanding of the areas covered using:

- Lectures (pre-recorded with live questioning) provide you with a focus on the core analytical material in the course, together with qualitative, alternative explanations to aid your understanding. These lectures are particularly interactive and all attendees will be required to participate;
- “Laboratories”, which are only for those who are unfamiliar with Matlab. They are hands-on and allow for exercises in problem solving and allow time for you to resolve problems in understanding of lecture material;
- Tutorials, which are specifically aimed to prepare students for the assessed assignments, and provide feedback on the assignments completed;
- Demonstrations to clarify with real examples how material covered in the lectures works in practice.

The lectures are stand-alone and cover one specific topic. The lectures are ordered such that there is a general introduction to satellite navigation, then the definition of the signals to be

processed, then the processing of those signals in the order in which the receiver performs the processing. Matlab tutorials give the student sufficient background to complete the Matlab-based assignments. The assignments themselves are aimed to give students experience of the material covered in lectures, to allow “learning by doing”. Demonstrations of receivers and visualisation software bring the theoretical discussions to life. Regular quizzes ensure the student is up to date with the lecture material.

Learning in this course

You are expected to attend all lectures and tutorials in order to maximise learning. In addition to the lecture notes/video, you should read relevant sections of the recommended texts and related technical materials. Group learning is also encouraged. UNSW *assumes* that self-directed study of this kind is undertaken in addition to attending face-to-face classes throughout the course.

The core material for the course is the set of lecture notes. All that is required for the course is contained within them. The lectures have been derived from several sources, the most important of which is the Kaplan textbook. If the student was to buy one textbook, this one is recommended. As with almost any software-based learning experience, there is no substitute for writing and running code. The more familiar the student is with the Matlab exercises, the more likely that person is to understand and be able to use the theoretical ideas presented in lectures.

Other Professional Outcomes

Engineers Australia, Professional Engineer Stage 1 Competencies

The learning outcomes of this course contribute to your development of the following EA competencies:

	EA Stage 1 Competencies	Course Learning Outcomes (CLOs)
PE1: Knowledge and Skill Base	PE1.1 Comprehensive, theory-based understanding of underpinning fundamentals	1, 2, 3, 4, 5
PE1.2 Conceptual understanding of underpinning maths, analysis, statistics, computing		1, 2, 3, 4, 5
PE1.3 In-depth understanding of specialist bodies of knowledge		1, 2, 3, 4, 5
PE1.4 Discernment of knowledge development and research directions		1,2,3,4,5
PE1.5 Knowledge of engineering design practice		1,2,3,4,5
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	1, 2, 3, 4, 5
PE2.2 Fluent application of engineering techniques, tools and resources		1, 2, 3, 4, 5
PE2.3 Application of systematic engineering synthesis and design processes		1, 2, 3, 4, 5
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)		1, 2, 3, 4, 5
PE3.3 Creative, innovative and pro-active demeanour		1, 2, 3, 4, 5
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		

Additional Course Information

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Assessments

Assessment Structure

Assessment Item	Weight	Relevant Dates
Final Quiz Assessment Format: Individual	30%	
In-class quizzes Assessment Format: Individual	10%	
Assignments Assessment Format: Individual	60%	

Assessment Details

Final Quiz

Assessment Overview

This is a 2-hour multiple choice exam at the end of the term. It will cover all lecture topics covered in the course, and it will follow the same format as the in-class quizzes.

Course Learning Outcomes

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- CLO4 : Make sound decisions about a GPS solution for integration within a larger system, based on your knowledge of how GPS components affect performance,
- CLO5 : Make an educated selection of GNSS receiver from those receiving GPS, Glonass, WAAS, Galileo, QZSS signals on the L1, L2, L5, E5 and E6 frequencies.

Assessment Length

2 hours

In-class quizzes

Assessment Overview

There are four 20-minute multiple-choice quizzes, each worth 2.5%. They are formative assessments to provide ongoing feedback on materials covered throughout the term, and preparation for the final quiz.

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Assignments

Assessment Overview

There are 3 assignments:

1. Process real GNSS position data 15%;

2. Process real off-air signals 20%;

3. Presentation on a research topic 25%

Each requires a report. The first is a group assignment. The second requires a Matlab program and the third an in-class presentation.

Course Learning Outcomes

- CLO1 : Explain how satellite navigation systems work and how they interact with each other
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General Assessment Information

Assessments will be discussed in detail Week 1.

Grading Basis

Standard

Requirements to pass course

Overall pass mark of 50%

Course Schedule

Teaching Week/Module	Activity Type	Content
Week 1 : 12 February - 18 February	Blended	Lectures: Introduction to Radionavigation Introduction to GPS GPS Signal Specification
Week 2 : 19 February - 25 February	Blended	Lectures: Navigation Message Positioning Principles Activities: GPS Rx Demo
Week 3 : 26 February - 3 March	Blended	Lectures: Positioning Errors Datums Assessment: Quiz 1 (Assignment 1 Available)
Week 4 : 4 March - 10 March	Blended	Lectures: Differential GPS Augmentation Systems Assessment Assignment 1 Tutorial: Preparation
Week 5 : 11 March - 17 March	Blended	Lectures: Receiver Architectures; RF Front End and Antennas Correlators Assessment Quiz 2 (Assignment 1 due)
Week 6 : 18 March - 24 March	Blended	Lectures: Tracking Loops Real GPS Data Namuru Assessment (Assignment 2 Available)
Week 7 : 25 March - 31 March	Blended	Lectures: Interference Weak Signal/ Assisted GPS Assessment Quiz 3 Assignment 2 Tutorial: Feedback/Preparation
Week 8 : 1 April - 7 April	Blended	Lectures: Multi-GNSS GPS L2C/L5 Signals Galileo Signals and Receivers Assessment (Assignment 2 due) (Assignment 3 Available)
Week 9 : 8 April - 14 April	Blended	Lectures: Glonass/ Beidou/ QZSS (Easter) GNSS in Society Assessment Quiz 4 Assignment 3 Tutorial: Feedback/Preparation
Week 10 : 15 April - 21 April	Blended	Assignment 3 Presentations (Assignment 3 due)

Attendance Requirements

Students are strongly encouraged to attend all classes and review lecture recordings.

Course Resources

Prescribed Resources

COURSE RESOURCESTextbooksPrescribed textbook

- Elliott D Kaplan and Christopher Hegarty, “Understanding GPS: Principles and Applications (2nd ed)”, Artech House, ISBN: 978-1-58053-895-4, 2005

Reference books

- James B-Y Tsui, “Fundamentals of Global Positioning Receivers: A Software Approach (2nd ed)”, Wiley, ISBN: 978-0-471-70647-2, 2005
- Borre, K., Akos, D.M., Bertelsen, N., Rinder, P., Jensen, S.H. , “A Software-Defined GPS and Galileo Receiver: A Single-Frequency Approach”, Birkhäuser, ISBN: 978-0-8176-4390-4, 2007
- Bradford W. Parkinson, James J. Spilker Jr., “Global Positioning System: Theory and Applications”, vols I & II, American Institute of Aeronautics and Astronautics, ISBN: 978-1-56347-249-7, 1996

On-line resourcesMoodle

As a part of the teaching component, Moodle will be used to disseminate teaching materials, host forums and provide news. Assessment marks will also be made available via Moodle: https://moodle.telt.unsw.edu.au/login/index.php.

Mailing list

Announcements concerning course information will be given in the lectures and/or on Moodle and/or via email (which will be sent to your student email address).

Recommended Resources

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Additional Costs

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Course Evaluation and Development

Continual Course Improvement

This course is under constant revision in order to improve the learning outcomes for all students. Please forward any feedback (positive or negative) on the course to the course convener or via the myExperience process. You can also provide feedback to ELSOC who will raise your concerns at student focus group meetings. As a result of previous feedback obtained for this course and in our efforts to provide a rich and meaningful learning experience, we have continued to evaluate and modify our delivery and assessment methods. Specifically with respect to 2020 feedback, assignment 1 has been made a group activity to increase student interaction.

Staff Details

Position	Name	Email	Location	Phone	Availability	Equitable Learning Services Contact	Primary Contact
Convenor	Andrew Dempster		G17 409	56890	-	No	Yes
Demonstrator	Phu Le		EEB 409	-	email	No	No

Other Useful Information

Academic Information

I. Special consideration and supplementary assessment

If you have experienced an illness or misadventure beyond your control that will interfere with your assessment performance, you are eligible to apply for Special Consideration prior to, or within 3 working days of, submitting an assessment or sitting an exam.

Please note that UNSW has a Fit to Sit rule, which means that if you sit an exam, you are declaring yourself fit enough to do so and cannot later apply for Special Consideration.

For details of applying for Special Consideration and conditions for the award of supplementary assessment, please see the information on UNSW's Special Consideration page.

II. Administrative matters and links

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

- Attendance
- UNSW Email Address
- Special Consideration

- Exams
- Approved Calculators
- Academic Honesty and Plagiarism
- Equitable Learning Services

III. Equity and diversity

Those students who have a disability that requires some adjustment in their teaching or learning environment are encouraged to discuss their study needs with the course convener prior to, or at the commencement of, their course, or with the Equity Officer (Disability) in the Equitable Learning Services. Issues to be discussed may include access to materials, signers or note-takers, the provision of services and additional exam and assessment arrangements. Early notification is essential to enable any necessary adjustments to be made.

IV. Professional Outcomes and Program Design

Students are able to review the relevant professional outcomes and program designs for their streams by going to the following link: https://www.unsw.edu.au/engineering/student-life/student-resources/program-design.

Note: This course outline sets out the description of classes at the date the Course Outline is published. The nature of classes may change during the Term after the Course Outline is published. Moodle or your primary learning management system (LMS) should be consulted for the up-to-date class descriptions. If there is any inconsistency in the description of activities between the University timetable and the Course Outline/Moodle/LMS, the description in the Course Outline/Moodle/LMS applies.

Academic Honesty and Plagarism

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, visit: 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.

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 or contract cheating) even suspension from the university. The Student Misconduct Procedures are available here:

www.gs.unsw.edu.au/policy/documents/studentmisconductprocedures.pdf

Submission of Assessment Tasks

Work submitted late without an approved extension by the course coordinator or delegated authority is subject to a late penalty of five percent (5%) of the maximum mark possible for that assessment item, per calendar day.

The late penalty is applied per calendar day (including weekends and public holidays) that the assessment is overdue. There is no pro-rata of the late penalty for submissions made part way through a day. This is for all assessments where a penalty applies.

Work submitted after five days (120 hours) will not be accepted and a mark of zero will be awarded for that assessment item.

For some assessment items, a late penalty may not be appropriate. These will be clearly indicated in the course outline, and such assessments will receive a mark of zero if not completed by the specified date. Examples include:

- Weekly online tests or laboratory work worth a small proportion of the subject mark;
- Exams, peer feedback and team evaluation surveys;
- Online quizzes where answers are released to students on completion;
- Professional assessment tasks, where the intention is to create an authentic assessment that has an absolute submission date; and,
- Pass/Fail assessment tasks.

Faculty-specific Information

Engineering Student Support Services – The Nucleus - enrolment, progression checks, clash requests, course issues or program-related queries

Engineering Industrial Training – Industrial training questions

UNSW Study Abroad – study abroad student enquiries (for inbound students)

UNSW Exchange – student exchange enquiries (for inbound students)

UNSW Future Students – potential student enquiries e.g. admissions, fees, programs, credit transfer

Phone

(+61 2) 9385 8500 – Nucleus Student Hub

(+61 2) 9385 7661 – Engineering Industrial Training

(+61 2) 9385 3179 – UNSW Study Abroad and UNSW Exchange (for inbound students)

School-specific Information

General Conduct and Behaviour

Consideration and respect for the needs of your fellow students and teaching staff is an expectation. Conduct which unduly disrupts or interferes with a class is not acceptable and students may be asked to leave the class.

Use of AI for assessments

Your work must be your own. If you use AI in the writing of your assessment, you must acknowledge this and your submission must be substantially your own work. More information can be found on this website.

Workplace Health & Safety (WHS)

WHS for students and staff is of utmost priority. Most courses involve laboratory work. You must follow the rules about conduct in the laboratory. About COVID-19, advice can be found on

this website.

School Contact Information

Consultations: Lecturer consultation times will be advised during the first lecture. You are welcome to email the tutor or laboratory demonstrator, who can answer your questions on this course and can also provide you with consultation times. ALL email enquiries should be made from your student email address with ELEC/TELExxxx in the subject line; otherwise they will not be answered.

Keeping Informed: Announcements may be made during classes, via email (to your student email address) and/or via online learning and teaching platforms – in this course, we will use Moodle https://moodle.telt.unsw.edu.au/login/index.php. Please note that you will be deemed to have received this information, so you should take careful note of all announcements.

Student Support Enquiries

For enrolment and progression enquiries please contact Student Services

Web

Electrical Engineering Homepage