ELEC9723
Satellite Navigation: Systems, Signals and Receivers

Course Outline – Semester 1, 2015

Never Stand Still | Faculty of Engineering | School of Electrical Engineering and Telecommunications

Course Staff

Course Convener: Prof Andrew Dempster, Room 129, a.dempster@unsw.edu.au
Lecture/Laboratory Support: Dr. Ediz Cetin, Room 127, e.cetin@unsw.edu.au

Consultations: You are encouraged to ask questions on the course material, during the allocated lecture class times in the first instance, rather than via email. Lecturer consultation times will be advised during lectures. You are welcome to email staff, 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.

Staff absences during session: Prof Dempster will be off campus on particular days but has no specific lecture dates he will be absent in 2015. During these times he can be contacted by email at the above email address. Also, on campus assistance with this course can be obtained from the above assistants during the period Prof Dempster is away.

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.

Course Summary

Contact Hours

The course has 3 hours timetabled per week. In the early weeks, this will consist of 2 hours of lectures, and a 1-hour laboratory session. In later weeks, this pattern will change – see the program below. Lectures will be recorded and made available on Moodle, technology permitting.

Lectures/ Laboratories	Day	Time	Location
	Thursday	3pm - 6pm	Quad G25

Context and Aims

The course is an elective in EET and CVEN programs:

8338 MEngSc Satellite Systems Engineering/ Electrical Engineering/ Telecommunications

8651 MEngSc Surveying and Spatial Information Systems/ Spatial Information Systems

The aim of the course is to provide an introduction to GPS and other satellite navigation systems, their signals and how they are processed to provide a position in a receiver. The course also provides details about GPS vulnerability and augmentation systems.

Indicative Lecture Schedule

Wk No.	Thursday 3-4 pm Quad G25	Thursday 4-5 pm Quad G25	Thursday 5-6 pm Quad G25
1	Introduction to Radionavigation	Introduction to GPS	**Matlab Tutorial 1 Introduction**
2	GPS Signal Specification	Navigation Message	**Matlab Tutorial 2 Graphics**
3	Positioning Principles	*GPS Rx Demo 1*	**Matlab Tutorial 3 Programming**
4	Positioning Errors	**Quiz 1** *Skyplot Demo*	Datums
5	Differential GPS	Augmentation Systems	**Assignment 1 Tutorial: Preparation**
	Easter	Break	
6	Receiver Architectures; RF Front End and Antennas	**Quiz 2**	Correlators **(Assignment 1 due)**
7	Tracking Loops	Real GPS Data	*GPS Rx Demo 2*
8	Namuru	**Quiz 3** Interference	**Assignment 2 Tutorial: Feedback/Preparation**
9	Weak Signal/ Assisted GPS	Multi-GNSS	*A-GPS Demo* **(Assignment 2 due)**
10	GPS L2C/L5 Signals	**Quiz 4** Galileo Signals and Receivers	
11	Glonass/ Beidou/ QZSS	Future of GNSS	**Assignment 3 Tutorial: Feedback/Preparation**
12	Assignment 3 Presentations	Assignment 3 Presentations	Assignment 3 Presentations
13	**Final Quiz**		

Assessment

Assessment for the course includes:

• Assignment 1	15%	Due week 6
• Assignment 2	20%	Due week 9
• Assignment 3	25%	Due week 12
• In-class quizzes	10%	Several weeks during session
• Final Quiz	30%	In week 13

***Laboratories**:*

Assignments 1 and 2 will be Matlab-based and will require writing of Matlab code. The laboratories in the early weeks are for those who have not used Matlab before. Assignment 3 will be a unique topic to research and will involve a presentation. The report for each assignment is required to have relevant theoretical background material, from lectures or textbooks, as well as reporting the actions taken and results produced.

Course Details

Credits

This is a 6 UoC course and the expected workload is 10–12 hours per week throughout the 13 week semester.

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.

Pre-requisites and Assumed Knowledge

There are no formal pre-requisites for this course. Entry into the relevant MSc program is considered the qualification. It is essential that you are familiar with basic electronics and signal processing before this course is attempted.

Learning outcomes

By the end of this session you should be able to:

1. understand how satellite navigation systems work and how they interact with each other;
2. understand 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;
3. select appropriate subsystems (e.g. antenna, RF front end) for a GPS receiver design;
4. make sound decisions about a GPS solution for integration within a larger system, based on your knowledge of how GPS components affect performance;
5. 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.

This course is designed to provide the above learning outcomes which arise from targeted graduate capabilities listed in ***Appendix A***. The targeted graduate capabilities broadly support the UNSW and Faculty of Engineering graduate capabilities (listed in ***Appendix B***).

This course also addresses the Engineers Australia (National Accreditation Body) Stage I competency standard as outlined in ***Appendix C***.

Syllabus

See Lecture Schedule

Teaching Strategies

Delivery Mode

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

- Formal face-to-face lectures, which 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.

Assessment

The assessment scheme in this course reflects the intention to assess your learning progress through the semester. Ongoing assessment occurs through the assignments and quizzes.

Quizzes

The quizzes in weeks 4, 6, 8 and 10 test your ongoing general understanding of the course material, and are designed to give you feedback on your progress. Questions may be drawn from any course material up to the time when the quiz is assigned, but in general will be only from material delivered since the previous quiz. It may contain questions requiring some (not extensive) knowledge of assignment material. Quizzes are all multiple choice.

Assignments

The assignments allow self-directed study leading to the solution of partly structured problems. For the first two assignments, marks are split equally between the Matlab program produced and its functionality, and the report describing the program. For the third assignment, marks are split equally between the presentation of the individual topic (peer assessed) and the report. Marks will be assigned according to how completely and correctly the problems have been addressed, the quality of the code written, and the understanding of the course material demonstrated by the report.

The assignment reports will be due at 1700 on the Fridays of weeks 6, 9 and 12. *Late reports will attract a penalty of 10% per day* (including weekends). Submission will be by email to the course coordinator.

Final Quiz

The final quiz is a closed-book 2 hour multiple choice examination, comprising forty questions. University approved calculators are allowed. The examination tests analytical and critical thinking and general understanding of the course material in a controlled fashion. Questions may be drawn from any aspect of the course, unless specifically indicated otherwise by the lecturer.

Special note about the marking of quizzes: Each quiz question has 5 possible answers. The student may give as many answers to each question as they think are possible, with one mark awarded for the correct answer and one quarter of a mark for incorrect answers. It is possible to attain negative marks.

Relationship of Assessment Methods to Learning Outcomes

	Learning outcomes						
Assessment	**1**	**2**	**3**	**4**	**5**		
Quizzes	✓	✓	✓	✓	✓		
Assignments	✓	✓	✓	✓	✓		
Final Quiz	✓	✓	✓	✓	✓		

Course Resources

Textbooks

Prescribed 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 resources

Moodle

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).

Other Matters

Academic Honesty and Plagiarism

Plagiarism is the unacknowledged use of other people's work, including the copying of assignment works and laboratory results from other students. Plagiarism is considered a form of academic misconduct, and the University has very strict rules that include some severe penalties. For UNSW policies, penalties and information to help you avoid plagiarism, see http://www.lc.unsw.edu.au/plagiarism. To find out if you understand plagiarism correctly, try this short quiz: https://student.unsw.edu.au/plagiarism-quiz.

Student Responsibilities and Conduct

Students are expected to be familiar with and adhere to all UNSW policies (see https://my.unsw.edu.au/student/atoz/ABC.html), and particular attention is drawn to the following:

Workload

It is expected that you will spend at least **ten to twelve hours per week** studying a 6 UoC course, from Week 1 until the final assessment, including both face-to-face classes and *independent, self-directed study*. In periods where you need to need to complete assignments or prepare for examinations, the workload may be greater. Over-commitment has been a common source of failure for many students. You should take the required

workload into account when planning how to balance study with employment and other activities.

Attendance

Regular and punctual attendance at all classes is expected. UNSW regulations state that if students attend less than 80% of scheduled classes they may be refused final assessment.

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.

Work Health and Safety

UNSW policy requires each person to work safely and responsibly, in order to avoid personal injury and to protect the safety of others.

Special Consideration and Supplementary Examinations

You must submit all assignments and attend all examinations scheduled for your course. You should seek assistance early if you suffer illness or misadventure which affects your course progress. All applications for special consideration must be **lodged online through myUNSW within 3 working days of the assessment**, not to course or school staff. For more detail, consult https://my.unsw.edu.au/student/atoz/SpecialConsideration.html.

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 Course and Teaching Evaluation and Improvement 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.

Administrative Matters

On issues and procedures regarding such matters as special needs, equity and diversity, occupational health and safety, enrolment, rights, and general expectations of students, please refer to the School and UNSW policies:
http://www.engineering.unsw.edu.au/electrical-engineering/policies-and-procedures
https://my.unsw.edu.au/student/atoz/ABC.html

Appendix A: Targeted Graduate Capabilities

Electrical Engineering and Telecommunications programs are designed to address the following targeted capabilities which were developed by the school in conjunction with the requirements of professional and industry bodies:

- The ability to apply knowledge of basic science and fundamental technologies;
- The skills to communicate effectively, not only with engineers but also with the wider community;

- The capability to undertake challenging analysis and design problems and find optimal solutions;
- Expertise in decomposing a problem into its constituent parts, and in defining the scope of each part;
- A working knowledge of how to locate required information and use information resources to their maximum advantage;
- Proficiency in developing and implementing project plans, investigating alternative solutions, and critically evaluating differing strategies;
- An understanding of the social, cultural and global responsibilities of the professional engineer;
- The ability to work effectively as an individual or in a team;
- An understanding of professional and ethical responsibilities;
- The ability to engage in lifelong independent and reflective learning.

Appendix B: UNSW Graduate Capabilities

The course delivery methods and course content directly or indirectly addresses a number of core UNSW graduate capabilities, as follows:

- Developing scholars who have a deep understanding of their discipline, through lectures and solution of analytical problems in tutorials and assessed by assignments and written examinations.
- Developing rigorous analysis, critique, and reflection, and ability to apply knowledge and skills to solving problems. These will be achieved by the laboratory experiments and interactive checkpoint assessments and lab exams during the labs.
- Developing capable independent and collaborative enquiry, through a series of tutorials spanning the duration of the course.
- Developing digital and information literacy and lifelong learning skills through assignment work.
- Developing ethical practitioners who are collaborative and effective team workers, through group activities, seminars and tutorials.
- Developing independent, self-directed professionals who are enterprising, innovative, creative and responsive to change, through challenging design and project tasks.
- Developing citizens who can apply their discipline in other contexts, are culturally aware and environmentally responsible, through interdisciplinary tasks, seminars and group activities.

Appendix C: Engineers Australia (EA) Professional Engineer Competency Standard

	Program Intended Learning Outcomes	
led ge an d	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	-