TELE4652
Mobile and Satellite Communications Systems

Course Outline – Semester 2, 2016

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

Course Staff

Course Convener: Dr. Derrick Wing Kwan Ng, Rm. MSB651, w.k.ng@unsw.edu.au

Consultations: You are encouraged to ask questions on the course material, after the lecture class times in the first instance, rather than via email. Lecturer consultation times will be advised during lectures. 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 TELE4652 in the subject line; otherwise they may 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.

Course Summary

Contact Hours

The course consists of 2 hours of lectures per week, one hour of tutorials per fortnight, and three hours of laboratories per fortnight. The Tutorials and Laboratories will begin in Week 2.

Lectures	Day	Time	Location
	Monday	13:00 - 15:00	Quad G044
Tutorials	Monday	15:00 - 16:00	Quad G044

The laboratories are held in EE322.

Context and Aims

The aim of this course is to provide students with a systems level understanding of two of the most important digital telecommunication systems; Cellular Mobile Communication Systems and Satellite Communication Systems. It will demonstrate how techniques such as digital modulation and channel coding, as are taught in TELE4653 – Digital Modulation and Coding, and TELE4651 – Wireless Communications Technologies, are used to improve the reliability and performance of each system. It also aims to provide a general understanding of the operation of these systems from a network perspective, with an emphasis on system architecture and system design.

The syllabus covers Propagation-Loss models, Mobile Fading Channels, Multiple Access techniques, the GSM and 3G standards, Digital Satellite Communication Systems, and Channel Diversity techniques. Central to the course is a detailed explanation of the

fundamental principles of the existing digital mobile communication: GSM, CDMA IS-95, cdma2000, 3G/UMTS, HSPA, and 4G/LTE. The emphasis of this course is less on the theoretical underpinnings of wireless communications, and more on how the conceptual building-blocks of wireless communication systems are implemented in real-world cellular and satellite communication systems.

In particular, the course aims to:

- Examine the challenges of mobile communications and the engineering solutions that have been developed to create commercial cellular networks.
- Present the structure, design, and functionality of each of the major existing cellular networks: GSM, IS-95, 3G, and 4G networks.
- Explain the algorithms and circuits used in the implementation of the current cellular mobile and satellite communication systems.
- Provide an insight into the latest developments and directions of research in modern cellular networks.
- Give an introduction to the field of satellite communications.

Indicative Lecture Schedule

Period	Summary of Lecture Program
Week 1	Introduction to Wireless Communications
Week 2	Cellular Concepts and Cellular Network Capacity
Week 3	Channel Modelling
Week 4	Effect of Fading and Remedies
Week 5	GSM Networks
Week 6	CDMA and IS-95
Week 7	UMTS W-CDMA and CDMA2000
Week 8	MIMO and Cross-Layer Scheduling **(Assignment 1 due)**
Week 9	4G and 5G Cellular Networks
Break	
Week 10	Satellite Channel Modelling and Antennas
Week 11	Satellite Link Budget Analysis
Week 12	Satellite Communications Systems – Satellite TV and GPS
Week 13	Overflow/Revision **(Assignment 2 due)**

Indicative Laboratory Schedule

Students must attend the laboratory every second week at their assigned time – either Even or Odd Weeks. The Even Week labs will be held in Weeks 2, 4, 6, 8, 10, & 12; while the Odd Week labs will be in Weeks 3, 5, 7, 9, 11, & 13.

A lab schedule will be posted on the course website by the start of Week 2. There are six experiments to complete, and each student will be assigned one experiment every lab session, with at most two students using each experimental apparatus per session. The laboratory exercises are as follows:

Lab 1 - Measurement of Antenna Radiation Patterns
Lab 2 - Microwave Measurement Techniques

Lab 3 - A Study of a Receive-only Satellite link
Lab 4 - Digital Modulation and Coding
Lab 5 - Study of GSM features using HP 8922M/S GSM test set
Lab 6 - Investigation of the CDMA (IS-95) system

Assessment

Laboratory Practical Experiments	20%
Lab Quizzes	5%
Assignments (x2)	20%
Final Exam (3 hours)	55%

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 course is a 4th year technical elective in the wireless communications discipline. It is aimed at students wishing to specialize in telecommunications in their degree, and possibly, their future careers.

Pre-requisites and Assumed Knowledge

A basic knowledge and understanding of communication systems and the communication problem, as would be gained from TELE3113, is assumed. Basic knowledge of Fourier theory, digital filters and signal processing is also assumed. Above average competency in the fields of algebra, analysis, and statistics, gained from the second year core mathematics courses, commensurate with a student wishing to specialize in telecommunications, will also be required.

The assignments and tutorials will require students to be familiar with MATLAB, or some other equivalent numerical computing platform. The laboratories are to be performed in EE322, the mobile communications laboratory. These laboratory tasks are quite challenging, performed on sophisticated hardware, and as such require students to have good experimental skills and preparation, as is expected from fourth year electrical engineering students.

Following Courses

As a final year technical elective, it is planned that the standard reached by students at the end of this course would be commensurate with that expected of a graduating telecommunications engineer. As a course focusing on real-world, practical systems and engineering solutions, it is hoped that this course will bring together many of the ideas taught in earlier courses, and allow students to understand how the concepts they have learnt at a more theoretical level are applied in actual existing communication systems, used in their everyday lives.

Learning outcomes

After successful completion of this course, you should be able to:

1. Be able to explain the network level structure and functionality of existing mobile and satellite communication systems.

2. Identify the factors that determine the capacity of mobile cellular and satellite communication systems.
3. Explain, with appropriate mathematical models, the practical implementation of the signal processing of the physical layer of mobile and satellite communication systems.
4. Be able to perform simple calculations to estimate the performance of various aspects of cellular network performance and digital communication systems.
5. Perform satellite link budget analysis.
6. Be aware of modern trends in research and development of communication systems.

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

Introduction to Mobile Communications: historical development of mobile telephony. Mobile Communications: Cellular concept, Antennae and Antenna Arrays, Radio propagation and transmission, Multi-path fading, Multiple Access techniques, modulation techniques for mobile radio, and diversity in mobile communications, channel coding for Mobile Communication Systems, source coding fundamentals. Mobile Communication Standards: GSM, CDMA spread spectrum concept, IS-95 CDMA, evolution to 3G networks (GPRS, EDGE), WCDMA, cdma2000 and UMTS-2000. Satellite Communications: Satellite radio, GPS.

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;
- Tutorials, which allow for exercises in problem solving and allow time for you to resolve problems in understanding of lecture material;
- Laboratory sessions, which support the formal lecture material and also provide you with practical construction, measurement and debugging skills;
- Fortnightly quizzes, conducted at the beginning of each laboratory. The motivation of these quizzes is to encourage students to keep up to date with the course material and concepts;
- Assignments, which allow you to explore a particular aspect of the course material in depth (for example, CDMA systems).

Learning in this course

You are expected to attend all lectures, tutorials, labs, and mid-semester exams in order to maximize learning. You must prepare well for your laboratory classes and your lab work will be assessed. In addition to the lecture notes/video, you should read relevant sections of the recommended text. Reading additional texts will further enhance your learning experience.

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.

Lectures

The lectures will focus on the theoretical analysis of cellular and satellite communication systems, along with a detailed description of existing networks and standards. The fundamental principles and specific network implementations will be illustrated with examples and simulations. Attendance at the lectures is compulsory, and moreover students are expected to prepare for the lecture in advance, as the formal notes will be available prior to each lecture. The lecture slides will take a different perspective from these written notes, and both these constitute examinable material.

Tutorial classes

You should attempt all of your problem sheet questions in advance of attending the tutorial classes. The importance of adequate preparation prior to each tutorial cannot be overemphasized, as the effectiveness and usefulness of the tutorial depends to a large extent on this preparation. Group learning is encouraged. Answers for these questions will be discussed during the tutorial class and the tutor will cover the more complex questions in the tutorial class.

Tutorials will begin in week 2. It is recommended that students attend a tutorial every second week. However, there is sufficient material, in the form of both questions and topics, so that each tutorial will cover slightly different questions every week, so students may wish to attend tutorials every week, particularly if they are struggling with a certain concept.

Laboratory program

Students must attend the laboratory every fortnight at their allotted time. If students find they must miss a lab session for any reason (illness, family or work commitments), they are required to contact the lecturer and make alternative arrangements PRIOR TO the lab session in question. Students who have not done so will receive a mark of 0 for the missed lab session – there will be no exceptions. Some lab periods may need to be rescheduled due to public holidays, and the announcement of alternative arrangements will be made during the lectures. Students should view the access to these labs as a great privilege, and take them very seriously.

There are 6 experiments to complete in total. All experiments will be performed in the Mobile Communication Lab in EE322, unless otherwise advised. The lab sheets will be made available on the course website at the start of the session. In the first week, once enrolment numbers are finalized, the exact schedule of the lab program will be determined.

Laboratory Exemption

There is no laboratory exemption for this course. Regardless of whether equivalent labs have been completed in previous courses, all students enrolled in this course for Semester 2, 2015 must take the labs. If, for medical reasons, (note that a valid medical certificate must be provided) you are unable to attend a lab, you will need to apply for a catch-up lab during another lab time, as agreed by the Course Convener.

Assessment

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

Laboratory Assessment

Laboratories are primarily about learning, and the laboratory assessment is designed mainly to check your knowledge as you progress through each stage of the laboratory tasks. A satisfactory performance (70% or above) in the lab component is a requirement to passing this course. Students must be marked off by a lab demonstrator at the end of each lab session and have their mark recorded by the demonstrator. It is the responsibility of the student to make sure this is done. If no mark is recorded at the end of the lab for whatever reason, a mark of 0 will be given – once again, there will be no exceptions.

Students are required to maintain a laboratory journal, and the marks obtained directly correspond to the quality of this journal. The journal should record all equipment settings and connections, as well as any measurements and observations made. It is important for all engineers to accurately document all experimental work, and emphasis is placed on the lab journal in this course to ensure that students develop this important attribute of a professional engineer. The journal must be handed in for assessment at the end of the laboratory program.

In order to get the most out of the labs, it is strongly recommended that you prepare for the laboratory before attending. This would involve reading through the laboratory sheet and performing any initial calculations. This would ensure you maximize the effectiveness of your time in the laboratory.

Assessment marks will be awarded according to how much of the lab you were able to complete, your understanding of the experiments conducted during the lab, the quality of the lab journal record, and your understanding of the topic covered by the lab.

Lab Quizzes

At the beginning of each lab session there will be a small quiz that will be performed on Moodle (beginning at the first lab, in Week 2 or 3). The quiz will consist of 8 multiple choice questions, from topics covered in the most recent lectures and tutorials. These quizzes will only be available at the beginning of the lab period. Students who are late and miss the quiz for any reason will receive an automatic mark of 0 for that quiz – there will be no exceptions. Students who miss a lab for any reason will not be able to catch up on these quizzes.

The six multiple choice quizzes conducted on Moodle will together make up 5% of the final grade in this course. The final grade will consist of the best five quiz marks for each student, meaning every student can drop their lowest quiz mark. The quizzes are closed book tests.

Assignments

There will be two assignments, due in Weeks 8 and 13. These assignments will largely involve students implementing and simulating communication systems in MATLAB. Reasonable competency in programming is thus assumed, and students who for some reason lack this competency are expected to be able to find the necessary assistance themselves and on their own time.

The assignments are compulsory and form an important assessment component of this course. Late assignments will suffer a late penalty of 10% reduction in the maximum

attainable mark per day late, including weekends, with the submission date taken from the time when the assignment physically reaches the lecturer's hand. Each assignment must have the appropriate assignment coversheet, properly filed out. This coversheet can be downloaded from the School website (http://www.engineering.unsw.edu.au/electrical-engineering/forms).

Final Exam

The exam in this course is a standard closed-book 3-hour written examination. 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 (including laboratory), unless specifically indicated otherwise by the lecturer. Marks will be assigned according to the correctness of the responses. *Please note that you must pass the final exam in order to pass the course.*

Relationship of Assessment Methods to Learning Outcomes

Assessment	**1**	**2**	**3**	**4**	**5**	**6**
Laboratory practical assessments	✓	✓	✓	✓	✓	-
Lab quizzes	✓	✓	✓	✓	✓	✓
Assignments	-	✓	✓	✓	✓	-
Final exam	✓	✓	✓	✓	✓	✓

Course Resources

The lecturer will make available the set of slides/overheads used in each lecture on the course website, for additional reference. The material in these slides will differ from the printed notes, in presentation, depth, and order of coverage, adjusted for effective presentation and communication. This material is examinable as well.

Textbooks

No available textbook covers all course topics; however several textbooks would still be extremely useful to students for reference.

Recommended textbooks:

- T.S. Rappaport, "Wireless Communications, Principles and Practice"; Prentice Hall, 1996/2002.
- W. Stallings, "Wireless Communications and Networks, 2nd Ed."; Pearson Prentice Hall, 2005.
- B.A. Black, P.S. DiPiazza, B.A. Ferguson, D.R. Voltmer, and F.C. Berry, "Introduction to Wireless Systems"; Pearson Prentice Hall, 2008.

The following list of books will provide reference for various parts of the course, and can be found at the library as required.

Reference books:

- J. Proakis & M. Salehi, "Communication Systems Engineering", Prentice-Hall, 2nd Edition, 2002.
- S. Haykin, "Communication Systems", Wiley, 4th Edition, 2001.
- B. Lathi, "Modern Digital and Analog Communication systems", Holt Saunders, (most recent edition).

- L.W. Couch II, “Digital and Analog Communication Systems”, Prentice-Hall, 5th Edition, 1997.
- M. Mouly and M-B. Pautet, “The GSM System for Mobile Communications.” Telecomm Publishing, 1992.
- J. Eberspaecher, H-J. Voegel, and C. Bettstetter, “GSM Switching, Services, and Protocols”, John Wiley and Sons, 2001.
- A.J. Viterbi, “CDMA – Principles of Spread Spectrum Communication”, Addison Wesley, 1995.
- R.G. Gallager, “Principles of Digital Communication”, Cambridge University Press, 2008.
- A. Goldsmith, “Wireless Communications”; Cambridge University Press, 2008.
- M. Schwartz, “Mobile Wireless Communications”; Cambridge University Press, 2008.
- T. Pratt, C.W. Bostian, and J.E. Allnuty, John Wiley & Sons, 2002.
- N. Benvenuto, R. Corvaja, T. Erseghe, & N. Laurenti, “Communication Systems”, Wiley, 2007.
- V.K. Garg, “IS-95 CDMA and cdma2000: Cellular/PCS System Implementation” Prentice Hall, 2000.
- S.R. Saunders and A. Aragon-Zavala, “Antennas and Propagation for Wireless Communication Systems”, Wiley, 2007
- T.T. Ha, Theory and Design of Digital Communication Systems”, Cambridge University Press, 2011.

On-line resources

Moodle

As a part of the teaching component, Moodle will be used to disseminate teaching materials (lecture notes, tutorials and solutions, assignments, past exam papers, etc.), host forums and quizzes. 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 https://student.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://student.unsw.edu.au/guide), 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://student.unsw.edu.au/special-consideration.

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.

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

	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	