School of Electrical Engineering and Telecommunications

Term 2, 2021
Course Outline

TELE4652
Mobile and Satellite Communications

COURSE STAFF

Course Convener: Dr. Derrick Wing Kwa Ng, Room 415, 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 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.

COURSE SUMMARY

Contact Hours

The course consists of 3 hours of lectures, a 1-hour tutorial, and a 3-hour laboratory session each week.

	Day	Time	Location
Lectures	Tuesday	09:00 – 11:00 (Weeks:1-10)	Microsoft Teams Meeting
	Thursday	16:00 – 17:00 Weeks:1-4	Microsoft Teams Meeting
Tutorials	Thursday	17:00 – 18:00	Microsoft Teams Meeting/Face-to-Face
Labs	Monday	15:00 - 18:00 (Weeks:1,2, 4-10)	Microsoft Teams Meeting/Face-to-Face
	Wednesday	12:00 - 15:00 (Weeks:1-10)	Microsoft Teams Meeting/Face-to-Face
	Thursday	12:00 - 15:00 (Weeks:1-10)	Microsoft Teams Meeting/Face-to-Face
	Friday	15:00 - 18:00 (Weeks:1-10)	Microsoft Teams Meeting/Face-to-Face

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; Digital Cellular Mobile Communication Systems and Digital 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 Equalisation and Channel Diversity techniques. Central to the course is a detailed explanation of the fundamental principles of the existing digital mobile communication systems in Australia, as well as world-wide: GSM, CDMA IS-95, cdma2000, 3G/UMTS, HSPA, and 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, and 3G 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 Communication Networks
Week 2	Cellular Concepts and Cellular Network Capacity
Week 3	Mobile Radio Propagation Models
Week 4	Effect of Fading and Remedies
Week 5	Overview of GSM, Spread Spectrum Communications and IS-95
Week 6	Flexibility week
Week 7	Overview of 3G, 4G, and Beyond (Assignment 1 due)
Week 8	Satellite Communications: Introduction
Week 9	Satellite Communications: Link Budget Analysis
Week 10	Review & Preparation for Exam (Assignment 2 due)

Indicative Laboratory Schedule

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 Assessments	20%
Assignment x 2	30%
Final Exam (2 hours)	50%

COVID19 - Important Health Related Notice

Your health and the health of those in your class is critically important. You must stay at home if you are sick or have been advised to self-isolate by NSW health or government authorities. Current alerts and a list of hotspots can be found here. **You will not be penalised for missing a face-to-face activity due to illness or a requirement to self-isolate**. We will work with you to ensure continuity of learning during your isolation and have plans in place for you to catch up on any content or learning activities you may miss. Where this might not be possible, an application for fee remission may be discussed.

If you are required to self-isolate and/or need emotional or financial support, please contact the Nucleus: Student Hub. If you are unable to complete an assessment, or attend a class with an attendance or participation requirement, please let your teacher know and apply for special consideration through the Special Consideration portal. To advise the University of a positive COVID-19 test result or if you suspect you have COVID-19 and are being tested, please fill in this form.

UNSW requires all staff and students to follow NSW Health advice. Any failure to act in accordance with that advice may amount to a breach of the Student Code of Conduct. Please refer to the Safe Return to Campus guide for students for more information on safe practices.

COURSE DETAILS

Credits

This is a 6 UoC course and the expected workload is 15 hours per week throughout the 10-week term.

Relationship to Other Courses

This is a 4th year technical elective course in the School of Electrical Engineering and Telecommunications. It is aimed at students wishing to specialise 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 specialise 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, equalisation 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 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;

Learning in this course

You are expected to attend/or watch the video of all lectures, tutorials, labs, and mid-term exams in order to maximise 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 formal classes throughout the course.

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. In addition, during the tutorial class, 1-2 new questions that are not in your notes may be provided by the tutor, for you to try in class. These questions and solutions may not be made available on the web, so it is worthwhile for you to attend your tutorial classes to gain maximum benefit from this course.

Laboratory program

The laboratory schedule is deliberately designed to provide practical exposure to the concepts conveyed in lectures soon after they are covered in class. You are required to attend laboratory. Laboratory attendance WILL be kept, and you MUST attend at least 80% of labs.

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 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 laboratory coordinator.

ASSESSMENT

The assessment scheme in this course reflects the intention to assess your learning progress through the term. Ongoing assessment occurs through the lab checkpoints (see lab manual), lab exams and the mid-term exam.

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. You are required to maintain a lab book for recording your observations. A lab book is an A4 size notebook containing a mix of plain pages and graph sheets.

It is essential that you complete the laboratory preparation before attending the lab. You are required to write the aim of the experiment and draw the circuit diagram if any in your lab book. This will be verified and signed by your demonstrators in the lab. You will be recording your observations/readings in your lab book first and then completing and submitting the results sheet before leaving the lab.

After completing each experiment, your work will be assessed by the laboratory demonstrator. Both the results sheet and your lab book will be assessed by the laboratory demonstrator.

Assessment marks will be awarded according to your preparation (completing set preparation exercises and correctness of these or readiness for the lab in terms of pre-reading), how much of the lab you were able to complete, your understanding of the experiments conducted during the lab, the quality of the code you write during your lab work (according to the guidelines given in lectures), and your understanding of the topic covered by the lab.

Laboratory Exam

To check that you have achieved the practical learning outcomes for the course, you will be examined in the laboratory. Laboratory Exams are closed book practical exams that include basic analytical calculations and testing on engineering concepts. The exam questions will be based on what you have learned in your laboratory classes and lectures, and marks will be awarded for the correct understanding of practical and relevant theoretical concepts, correct operation of laboratory equipment, and correct interpretation of measured results.

Mid-Term Exam

The mid-term examination tests your general understanding of the course material, and is designed to give you feedback on your progress through the analytical components of the course. Questions may be drawn from any material already covered in the course schedule. It may contain questions requiring some (not extensive) knowledge of laboratory material, and will definitely contain numerical and analytical questions. Marks will be assigned according to the correctness of the responses.

Assignment

There will be two assignments, due in Weeks 7 and 10. 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 2 hour written examination, comprising five compulsory 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 (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

	Learning outcomes					
Assessment	**1**	**2**	**3**	**4**	**5**	**6**
Laboratory practical assessments and exam	✓	✓	-	✓	✓	✓
Assignment	✓	✓	✓	-	✓	-
Final exam	-	✓	✓	✓	✓	-

COURSE RESOURCES

Lecture Notes
A comprehensive set of typed lecture notes will available on the website. These typed lecture notes will take the role of the textbook, since no available textbook quite covers all the course material at the depth required of this course. These lecture notes are the reference of examinable material – they effectively play the role of the detailed course syllabus.

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

- W. Stallings, “Wireless Communications and Networks, 2nd Ed.”; Pearson Prentice Hall, 2005.
- T.S. Rappaport, “Wireless Communications, Principles and Practice”; Prentice Hall, 1996/2002.
- 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.
- 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.

In addition, 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.

On-line resources

Moodle

As a part of the teaching component, Moodle will be used to disseminate teaching materials, host forums and occasionally 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

Dates to note

Important Dates available at: https://student.unsw.edu.au/dates

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/policy), and particular attention is drawn to the following:

Workload

It is expected that you will spend at least **15 hours per week** studying a 6 UoC course, from Week 1 until the final assessment, including both formal classes and *independent, self-directed study*. In periods where you 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 can apply for special consideration when illness or other circumstances beyond your control interfere with an assessment performance. If you need to submit an application for special consideration for an exam or assessment, you must submit the application **prior to the start** of the exam or before the assessment is submitted, except where illness or misadventure prevent you from doing so. Be aware of the "fit to sit/submit" rule which means that if you sit an

exam or submit an assignment, you are declaring yourself well enough to do so and cannot later apply for Special Consideration. For more information and how to apply, see 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 online student survey myExperience. 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:
https://student.unsw.edu.au/guide
https://www.engineering.unsw.edu.au/electrical-engineering/resources

APPENDICES

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 Stage 1 Competency Standards

Competency Standards		Learning Outcomes
PE1: Knowledge and Skill Base	PE1.1 Comprehensive, theory-based understanding of underpinning fundamentals	1, 2, 4, 5, 6
	PE1.2 Conceptual understanding of underpinning maths, analysis, statistics, computing	1, 2, 4, 5, 6
	PE1.3 In-depth understanding of specialist bodies of knowledge	1, 2, 4
	PE1.4 Discernment of knowledge development and research directions	
	PE1.5 Knowledge of engineering design practice	1, 2, 4
	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, 4, 5
	PE2.2 Fluent application of engineering techniques, tools and resources	1, 2, 4, 5
	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)	3
	PE3.3 Creative, innovative and pro-active demeanour	3
	PE3.4 Professional use and management of information	3
	PE3.5 Orderly management of self, and professional conduct	
	PE3.6 Effective team membership and team leadership	3