School of Electrical Engineering and Telecommunications

Semester 1, 2018
Course Outline

PHTN 4661
Optical Circuits and Fibres

COURSE STAFF

Course Convener: Prof François Ladouceur, Room 647, f.ladouceur@unsw.edu.au
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Laboratory Contact: Prof François Ladouceur, Room 344, f.ladouceur@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 PHTN4661 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 2 hours of lectures per week, and 2 hours of laboratory sessions and tutorial per week:

	Day	Time	Location
Lectures	Monday	10:00 – 12:00	CLB 5
Labs	Tuesday	13:00 – 15:00	ChemSc 713
	Wednesday	15:00 – 17:00	ChemSc 713
Tutorials	Friday (even week)	14:00 – 16:00	Myers Theatre

Context and Aims

Optical circuits are miniaturised and integrated optical paths and devices onto a single planar substrate. They are commonly used in traditional optical telecommunications but are now finding new application fields in sensing, MEMs, astronomy and data transfer (chip-to-chip, board-to-board). The course aims to make student familiar with standard silica-on-silicon planar waveguide technology and its interface with standard telecom optical fibres. In that process, the student will be introduced to the modelling and design of optical circuits.

Indicative Lecture Schedule

Period	Summary of Lecture Program
Week 1	Waveguides + Silica
Week 2	Guidance + Definitions + Wave equations
Week 3	Modes + Slab waveguide + Modedness
Week 4	Optical fibres I + II
Week 5	Gaussian approximation
Break	
Week 6	
Week 7	Scattering + Bend loss + Splice loss + Transition loss
Week 8	Mode beating + Supermodes
Week 9	Perturbation theory + Mode coupling
Week 10	Propagation + BPM + path design
Week 11	Circuit design
Week 12	Overall review

Indicative Laboratory Schedule

Period*	Laboratory	Group
Week 2	Lab 1: Modes of rectangular waveguides	G1 + G2
Week 3	Lab 1: Modes of rectangular waveguides	G3 + G4
Week 4	Lab 2: Waveguide design: coupling	G1 + G2
Week 5	Lab 2: Waveguide design: coupling	G3 + G4
Break		
Week 6	Lab 3: Phase shifter	G1 + G2
Week 7	Lab 3: Phase shifter	G3 + G4
Week 8	Lab 4: Mode coupling	G1 + G2
Week 9	Lab 4: Mode coupling	G3 + G4
Week 10	Lab 5: Beam Propagation Method	G1 + G2
Week 11	Lab 5: Beam Propagation Method	G3 + G4

* The class will be divided in four laboratory groups G1–G4 determined at registration time. Flexibility will be allowed depending on availability.

Assessment

Laboratory Practical Experiments (5 experiments)	25%
Mid-Semester Quiz	25%
Final Exam (2 hours)	50%

COURSE DETAILS

Credits

This is a 6 UoC course and the expected workload is 10–12 hours per week throughout the 13-week semester including both face-to-face classes and *independent, self-directed study*.

Relationship to Other Courses

This is a 4th year elective course in the School of Electrical Engineering and Telecommunications. For those with a special interest, this course builds on the fundamental formalism associated with waveguides by exploring how they can be used to build functional optical circuits.

Pre-requisites and Assumed Knowledge

The pre-requisite for this course is ELEC3115, Electromagnetic Engineering. It is assumed that the students possess a good understanding of electromagnetism (e.g. Maxwell's equations), and have good computer literacy, in particular familiarity with MATLAB or Mathematica.

Following Courses

The course is a pre-requisite for PHTN4662 Photonics Networks.

Learning outcomes

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

1. Understand the typical applications of optical circuits;
2. Understand the coupling mechanisms with optical fibres;
3. Model using various techniques the basic building blocs of integrated circuits;
4. Design simple optical circuits (paths, phase shifters, interferometers, *etc.*)
5. Understand the limitations placed on optical circuits imposed by fabrication, losses and integration;

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

Types and applications of optical fibers; ray analysis of multimode fibres; characteristics of single-mode fibres including experiments; losses and dispersion in fibres; fibre fabrication; cabling and handling fibres. Waveguiding in integrated optics & fibres; fabrication processes, optical substrates; modelling methods, manufacturing constraints on design; Photonic devices: Operating principles & applications of waveguide-based devices, selected from the following list: tapers, couplers, polarisers, Bragg gratings, filters, interferometers, fibre lasers & amplifiers; Operation \& application of LEDs, lasers, & detectors.

TEACHING STRATEGIES

Delivery Mode

Lectures: During the lectures, integrated optics and related design issues are discussed and the appropriate theoretical framework is introduced. The lectures provide the students with a focus on the core material in the course and stresses the important conceptual advances. Numerous examples of optical integrated circuits are discussed in order to convey a qualitative understanding of their operations. Students are expected to attend the lectures and prepare themselves for them.

Virtual laboratories: The laboratory work will be based on an in-house software library. The student will be asked to use this library, in the form on MATLAB scripts/programs, to study various aspects of light propagation in optical circuits.

Learning in this course

You are expected to attend all lectures, tutorials, labs, and mid-semester 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 face-to-face 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, hands-on exposure to the concepts conveyed in lectures soon after they are covered in class. You are required to attend laboratory from Week 4 to Week 12. 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 semester. Ongoing assessment occurs through 5 lab reports and the mid-semester exam.

Laboratory Reports

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. Each assessment consists in a lab report to be submitted to your lecturer 2 weeks after the completion of the lab. It is essential that you complete the laboratory preparation before coming to the lab.

Mid-Semester Quiz

The mid-session quiz 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 course material up to the end of week 6. 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.

Final Exam

The exam in this course is a standard closed-book 2 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

	Learning outcomes				
Assessment	**1**	**2**	**3**	**4**	**5**
Laboratory assessments	✓	✓	-	✓	-
Mid-semester quiz	✓	✓	✓	✓	✓
Final exam	✓	✓	✓	✓	✓

COURSE RESOURCES

Textbooks

Prescribed textbook

- Ladouceur and J.D. Love, Silica Based Buried Channel Waveguides and Devices, Kluver.

Reference books

- R. März, Integrated Optics, Artech House, Boston.
- A.W. Snyder and J.D. Love, Optical Waveguide Theory, Kluver.
- Cambridge Illustrated Handbook of Optoelectronics and Photonics, Cambridge University Press.

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.

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/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 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. The virtual laboratories have been completely revamped and have move from C++ to MATLAB. This is in an effort to better leverage acquired knowledge from students who should have had wide exposure to MATLAB in the previous years of their degree.

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 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.

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	✓