ELEC9350

Optical Fibres

COURSE OUTLINE

Session 1, 2009

THE UNIVERSITY OF NEW SOUTH WALES

Faculty of Engineering

School of Electrical Engineering
& Telecommunications

Course Staff

Lecturer in charge: Prof G. D. Peng
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Other lecturer: Dr I Skinner
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Course Information

Credits: This is a 6 UoC postgraduate course.

Workload: The expected workload is 10–12 hours per week (including the contact hours) per week throughout the 12 week session. This workload should be sufficient for average students to acquire the required knowledge, understanding and skill from lectures, tutorials and lab experiments and to achieve satisfactory results.

Course Aims and Context

The course aims to ensure understand, and become familiar with, fundamental principles, theoretical methods and experimental techniques of optical fibres and related technologies, and enable the student to carry out basic optical fibre related analysis, design and measurement. The primary aim of this course is to provide students with a solid foundation in fibre optics and optical communication technologies.

This course will cover the following

Advantages & limitations of optical fibres

Single mode and multimode fibres

Optical fibre modal analysis & properties

Optical fibres: Attenuation, dispersion and bandwidth

Polarization & Birefringence in fibres

Fibre-based components

Optical fibre system design considerations

Manufacture of optical fibres and cables

Optical fibre measurement and experiment

Relation to other courses

The course is a professional elective offered to postgraduate students at the University of New South Wales. The course gives the foundations for fibre optics –optical fibres, fibre components and systems, fibre based photonic networks.

Pre-requisites: This course is essentially self-contained. There are no pre-requisites for this course.

Assumed knowledge: It is essential that the students are familiar with the fundamentals of electromagnetic theory, engineering mathematic methods and communication system theory. It is further assumed that the students have satisfactorily completed undergraduate courses in electrical engineering or physics. If you feel you don't have the appropriate background, then these books should help.

B.P. Lathi, *Modern Digital & Analog Communication Systems*
D.K. Cheng, *Field & Wave Electromagnetics*

Following courses: This course is followed by the post-graduate course ELEC9355.

Teaching strategies

The course consists of the following elements: lectures, laboratory experiments, tutorials and consultations. Effective learning can be achieved when you are actively engaged in the learning process and communicating and discussing freely with the course lecturer, lab demonstrator and fellow students.

Lectures: The lectures provide the students with a focus on the key concepts, principles and methods in the course. There will be a few notes handed out that cover some class materials but these will not be sufficient. Students should attend all the lectures and take notes during class.

Laboratory work: The laboratory work provides the student with hands-on experience and exposure to various optical fibres, optical components and optical measurement systems. The laboratory sessions are short. Students must come well prepared for the laboratory sessions.

Tutorials: The tutorials provide the student with problems and questions directly linked to quantitative and qualitative understanding of optical fibre materials, physical properties, modelling, analysis, design and application of optical fibres. The tutorials take the student through most of course topics and aim to make the students familiar with technical considerations, issues and methods in solving problems and questions in optical fibres. Only some of problems will be discussed in tutorial sessions. The students are strongly encouraged to complete all the tutorial questions by themselves or in small groups.

Consultations: Students are strongly encouraged to consult the course lecturer during and after lecture or tutorial time regarding any questions, problems or difficulties. Students may seek consultation with the course lecturer at other times by appointment. If necessary, regular consultation times could be arranged.

Expected learning outcomes

By finishing this course satisfactorily you are expected to

Know how to use the main theoretical methods for modeling and analysing optical fibres;

Know the fundamental properties of multi-mode and single-mode optical fibres;

Understand the main technical issues and considerations when using optical fibres in communication systems and networks;

Be familiar with the main experimental methods and measurement techniques of optical fibres; and

Know general aspects of optical fibre design, manufacture and application.

UNSW Graduate Attributes

This course is designed to provide opportunities that foster students core UNSW graduate attributes, in particular:

1. *The skills in scholarly enquiry and the in-depth engagement with relevant disciplinary knowledge and technical issues through lectures, laboratory experiments and tutorial questions;*
2. *The extended capacity for analytical and critical thinking and for creative problem-solving, by emphasizing theoretical analysis methods, the laboratory experiments and tutorial exercises;*
3. *The ability to engage in independent and reflective learning, which is addressed by the laboratory experiments;*
4. *The skills of effective technical communication, which are addressed and assessed by the laboratory reports and final examination.*

Course Schedule

Course timetable

Lecture:	18:00-21:00 Thursday, Week 1 and Week 12	EE222
	18:00-19:30 Thursday, Week 2 to Week 11	EE222
Tutorial:	19:30-21:00 Thursday, Week 2 and Week 11	EE222
Laboratory:	19:30-21:00 Thursday, Week 2 to Week 11	EE347

Course context

Week 1 *(I M Skinner)*
Introduction and review, introduction to lab work

Snell's law, Fresnel reflection, TEM waves, Fibre types,
Advantages & limitations, Basic structure
Fibre loss, OTDR, Index profile, Cut-off wavelength,

Week 2&3 *(I M Skinner)*
Analysis model and method I
Ray analysis- Acceptance angle, Numerical aperture
Impulse response
Step index multimode fibres, Graded-index multimode fibres

Modal analysis
Weak guidance, Boundary conditions, Eigenvalue equation, modal cut-off, modal fields. Guided and unbound modes

Week 4 *(G D Peng)*
Fibre materials & fabrication: silica and silicate glasses, dopants, polymers
Fibre experiment I: preliminary practice

Week 5 *(G D Peng)*
Attenuation and related issues
Attenuation and absorption mechanisms
Bending and microbending losses in fibres. Tapered Fibres

Week 6 *(G D Peng)*
Analysis model and method II
Approximation methods
Equivalent step index, Spot-sizes
Dispersion and bandwidth
Material dispersion, Modal dispersion, Waveguide dispersion, Bandwidth and pulse broadening
Dispersion in step-index multimode fibre. Dispersion in graded-index multimode fibres

Week 7 *(G D Peng)*
Fibre experiment II

Week 8 *(G D Peng)*
Midterm Exam

Week 9 *(G D Peng)*
Anisotropy, Birefringence / Polarisation
System design issues and considerations
Launching, jointing and connecting fibres
Launching efficiencies and jointing losses, connectors
Power budget, Bandwidth budget, System design issues

Week 10 *(G D Peng)*
Fibre experiment III

Week 11 *(G D Peng)*
Fibre-based components
Couplers, Fibre Bragg gratings, EDFA, sensing elements

Week 12 *(G D Peng)*
Current research topics
Course review

Assessment

Your final mark is determined by three parts:

Laboratory Work	15 %
Middle Term Exam	20 %
Assignment	5 %
Final Examination	60 %

Laboratory work assessment:
Engineering labs are potentially dangerous places; rooms 347 & 348 are no exceptions. **Students' behaviour must conform at all times to the rules applying to the School's laboratories.** Also, when conducting your experiments you will need to be aware of any specific hazards (eg sharp materials) associated with them. Students are responsible for their own conduct and share responsibility for the safety of all people in the laboratories.

Details about the lab programme will be handed out separately.

Middle term examination:
The middle-term exam will be closed-book 1.5 hour written examination.
University approved calculators are allowed. The examination tests general understanding of the course materials covered up to the middle-term.

Assignment:
Assignment will be handout by Week 5 and submitted by Thursday Week 9.

Final examination: The final exam will be 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. Assessment is a graded mark according the correct fraction of the answers to the exam questions.

Resources for Students

Textbooks

We do not prescribe a textbook. We recommend you have either of these as a main reference book:

J. Senior (1992), *Optical Fibre Communications*, 2nd ed, Prentice-Hall
G. Keiser (2000), *Optical Fibre Communications,* 3rd ed, McGraw-Hill

Students are encouraged to purchase one of these books as is provides the most coverage of the topics in this course and also its following course: ELEC9355. There are also quite a few copies of them in the UNSW library.

Course materials

Course related materials and notes will be handed out in class during the session.

Lect. 1 Introduction
Ref: Lecture notes; Senior: Chapter 1; Keiser: Chapter 1;
Fibre loss, OTDR, Index profile, Cut-off wavelength, Spot-size.

Ref: Lecture notes and lab notes; Senior: Chapter 13; Keiser: Chapter 13;

Lect. 2 & 3 Analysis model and method
Ref: Senior: Chapter 2; ; Keiser: Chapter 2

Lect. 4 Optical fibre materials and fabrication
Fibre materials & fabrication, silica and silicate glassess, dopants, polymers
Fibre cable designs, protection and aging
Ref: Senior: Chapter 4; Keiser: Sections 2.27-2.10;

Lect. 5 Attenuation and related issues
Attenuation and absorption mechanisms
Bending and microbending losses in fibres. Tapered Fibres
Ref: Senior: Sections 3.1-3.9; Keiser: Section 2.7, 3.1 and 3.5.5

Lect. 6 Analysis model and method II: Approximation methods
Equivalent step index, Spot-sizes, Momentum method
Ref: Lecture notes; Senior: Section 2.5.6;

Lect. 9 Polarisation and birefringence in optical fibres
Polarisation states. Anisotropy and birefringence. Polarisation effects in fibres.
Birefringent fibres, fibre-optical polarization components
Ref: Senior: Sections 3.13 and 12.4.2; Keiser: 2.1.1;

Lect. 11 Fibre based components
Ref: Lecture notes

Lect. 12 Current research topics & review
Ref: Lecture notes

Academic Honesty and Plagiarism

Plagiarism is the unacknowledged use of other peoples work, including the copying of assignment works and laboratory results from other students. Plagiarism is considered a serious offence by the University and severe penalties may apply. For more information about plagiarism, please refer to http://www.lc.unsw.edu.au/plagiarism

Course Evaluation and Improvement

Students are advised that the course is under constant revision in order to improve the learning outcomes of its students. Please forward any feedback (positive or negative) on the course to the course lecturer or via the Course and Teaching Evaluation and Improvement (CTAI) process.

Administrative Matters

You need to be informed on the School's and University's policies about students' responsibilities, academic & other misconduct, special consideration, conduct of examinations, and the submission & assessment of assignments as well as students’s equity and diversity, occupational heath and safety, enrolment and rights. Such policies can be found at www.ee.unsw.edu.au and www.student.unsw.edu.au/atoz, respectively.

Any student who, by reason of disability, needs modification of his/her teaching or learning environment is encouraged to contact us or the University's Equity Officer (Disability) on 9385 4734.

Notices about this course will be available on the board outside rooms EE347.