PHTN321

Optical and Photonic Devices and Systems 1

S1 Day 2016

Dept of Physics and Astronomy

Contents

General Information

Unit convenor and teaching staff Convenor and lecturer Deb Kane deb.kane@mq.edu.au Contact via email in first instance E6B 2.701 Lecturer Mike Steel michael.steel@mq.edu.au Contact via email in first instance E6B 2.713 Lecturer Luke Helt luke.helt@mq.edu.au Contact via email in first instance E6B 2.405 Laboratory Professional Officer Regiona Dunford regina.dunford@mq.edu.au Contact via email in first instance E7B 252 (entry via photonics labs) Deb Kane deb.kane@mq.edu.au
Credit points 3
Prerequisites PHYS201 and PHYS202
Corequisites
Co-badged status

Unit description
Lasers and optical waveguides (including optical fibres) are critical to the operation of most optical technologies. The physical principles of these devices are discussed in detail in this unit, and some applications in optical communications, industry and biophotonics are presented. Related laboratory work in lasers, laser applications and single-mode optical fibres is included.

Important Academic Dates

Information about important academic dates including deadlines for withdrawing from units are available at https://www.mq.edu.au/study/calendar-of-dates

Learning Outcomes

On successful completion of this unit, you will be able to:

- You should understand and be able to describe the fundamental physics underpinning laser gain and oscillation, as well as the physical processes that govern a wide range of laser systems.
- You should be able to quantitatively predict the output and the behaviour of a laser as a function of relevant system parameters. You should be able to explain how the unique properties of lasers are exploited for different applications, and identify appropriate lasers for different situations.
- You should understand and be able to describe mathematically the fundamental physics underpinning optical fields in waveguides. You should be able to explain the role and mathematics of optical waveguide modes and derive and apply dispersion relations for simple waveguide geometries.
- You should be able to model quantitatively the propagation of light in various waveguide geometries and have insight into the properties of a range of different waveguides. You should be able to explain how waveguides are used to modify the propagation of light through linear and nonlinear optical effects, especially dispersion and loss, and how these may be exploited in practical applications.
- You should be able to explain some of the approaches to optical fibre fabrication and installation and appreciate the unique properties of long-haul single mode fibres and erbium-doped optical fibre amplifiers that have together enabled the optical communications revolution.
- You should have an operational capability to use optical detectors, diagnostics and measurement instruments, and an understanding of the physics of various optoelectronic phenomena. You should have confidence and capability to use and operate key optical

diagnostic equipment.

Assessment Tasks

Name	Weighting	Due
Assignments	20%	Approximately fortnightly
Laboratory reports	30%	one week after each experiment
Final Examination	50%	See Examination Timetable

Assignments

Due: **Approximately fortnightly**
Weighting: **20%**

Six problem sets will be given out spread through the session, three from each half of the course. The assignments are the key opportunity to develop and practice skills in calculation and analysis in preparation for the exam.

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communications revolution.

Laboratory reports

Due: **one week after each experiment**
Weighting: **30%**

You must record your experimental data and deliberations in a laboratory book. A brief laboratory report summarising the aims, results, analysis and discussion of the experiment, and prepared in hardcopy loose leaf form is to be handed in, one for each weekly experiment within one week of completion of the experiment. Penalties for late submission may be imposed. Your lab book must be available for checking each week and at the end of semester. Attendance at Laboratories is compulsory, and all lab reports **must** be submitted in order to pass the course.

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Final Examination

Due: **See Examination Timetable**
Weighting: **50%**

You should have a scientific calculator for use during the final examination. Note that calculators with text retrieval are not permitted for the final examination.

The examination will be in two parts, A and B, and will be of three hours duration plus ten minutes reading time. Parts A and B will consist of three questions each, all of which are compulsory. Part A questions refer to the first half of the unit, and Part B questions refer to the second half of the unit.

Previous year's examinations will be a useful guide to the format and type of content of this year's exam.

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Delivery and Resources

There is no required text book

Handouts will be distributed regularly during the lectures, via email and/or will be available for downloading from the unit web-page.

Recommended reading

O Svelto, Principles of Lasers, (NY, Plenum Press, 1998), QC688.S913/1998

AE Siegman, Lasers, (Mill Valley, CA, Oxford, 1986), TA1675.S54/1986

BEA Saleh and MC Teich, Photonics, (New York, Wiley, 1991), TA1520.S24/1991

AW Snyder and JD Love, Optical Waveguide Theory, (London, Chapman and Hall, 1983), TA1800.S69/1983

Other Library Resources

CC Davis, Lasers and Electro-optics, (Cambridge, Cambridge U Press, 1996), TA1675.D38

TTamir, Guided-Wave Optoelectronics, (Berlin, Springer-Verlag, 1990), TA1750.G85/1990

DL.Lee, Electromagnetic Principles of Integrated Optics, (New York, Wiley, 1986), TA1660.L44/1986) AB Buckman, Guided-Wave Photonics, (Fort Worth, Saunders, 1992), TA1660.B83/1992

KJ Ebeling, Integrated Optoelectronics, (New York, Springer-Verlag, 1992), TA1750.E2413/1993

Teaching Strategy

The unit is taught through a combination of lectures and tutorial style classes, with weekly or fortnightly problem- based assignments. Practical and report writing experience is provided through the laboratory sessions.

You are expected to submit assignments and lab reports on separate sheets, weekly, or as required. You are also expected to read reference texts or lab resource material for each experiment, as requested by the lecturer or demonstrator.

Laboratory (Lab) Sessions

The laboratory will operate on Wednesday (12 noon to 3 pm) **commencing week 1**. Access to the laboratory at other times may be possible by arrangement. You must finish one experiment at a time, and each experiment is expected to require one 3-hour laboratory session. Laboratory work is an extremely important part of the unit.

You should have a scientific calculator for use during the laboratory sessions.

It is very important to submit each week's laboratory report at the next scheduled lab session. The report will then be marked and returned to you during the following lab session. That way your skills with writing laboratory reports can rapidly develop.

The following photonics experiments will be available, subject to any unforeseen equipment problems:

- Diode-pumped Nd:YAG laser
- Acousto-optic effect
- Laser Doppler velocimetry
- Scanning confocal interferometer
- Second-Harmonic Generation
- Tunable diode laser spectroscopy
- Single mode optical fibres: Gaussian mode, fibre coupling
- Polarisation maintaining optical fibres
- Single mode fibre sensors and interferometers
- Fibre amplifiers
- Fibre lasers

Prize

Students studying this unit are eligible to be considered for the JC Ward Prize awarded for overall excellence in four 300-level units in Physics.

Technologies used and required

Assignments may require software on the computers in the PC lab E7B.209. The laboratory contains a large amount of highly specialised equipment.

Unit Schedule

Lasers and optical waveguides are the most fundamental components of optical and photonic systems. Good examples are optical telecommunication networks where information is encoded on laser pulses that are transmitted via optical fibres. In this unit, practical and theoretical aspects of lasers and of light propagation in waveguide structures are developed.

In the first half of the unit, fundamental aspects of laser-gain materials are discussed. Knowledge about optical transitions and line broadening mechanisms, as well as about properties of passive optical resonators will form the basis for a study of laser performance in terms of threshold, modes and pulsed operation. Laser safety is also discussed.

In the second half of the unit, the principles of electromagnetic theory are applied to dielectric waveguides including optical fibres, 3dB couplers and graded-index structures. Particular emphasis is placed on determining the modes of such systems and the resonance conditions for waveguide modes. The description of linear propagation and the physics of dispersion is explored in detail.

The practical component of the unit provides a valuable preparation for working in the field of photonics,using modern laboratory equipment. Proficiency in practical work is regarded as important, and lab involving modulators, laser modes, detectors and detection systems are offered.

Lecture program

First Half (Prof Deb Kane)

Lasers

- *Week 1:* Fundamental properties of light; Laser safety, Light-Matter interaction; Lineshape function; 2-level systems; Saturation of absorption
- *Week* 2: 3-level and 4-level systems; Gain coefficient; Optical amplifiers
- *Week 3:* Resonator losses; Laser characteristics; Slope efficiency; Longitudinal resonator modes
- *Week 4:* Pulsed lasers, Relaxation oscillations, Q-switching, Mode-locking
- *Week 5:* Optical Resonators, Transverse resonator modes, Gaussian beams
- *Week 6:* Semiconductor lasers and integrated photonics

Second Half (A/Prof Mike Steel)

Optical Waveguides

- *Week 7*: Review of Maxwell's equations and the wave equation
- *Week 8*: TE and TM modes of simple waveguides
- *Week 9*: Transverse resonance condition and universal curves
- *Week 10*: Graded refractive index and optical fibres
- *Week 11*: Propagation and nonlinear optics in waveguides
- *Week 12*: Fabrication and applications of waveguides
- *Week 13*: Revision

Timing may vary relative to this schedule

Policies and Procedures

Macquarie University policies and procedures are accessible from Policy Central. Students should be aware of the following policies in particular with regard to Learning and Teaching:

Academic Honesty Policy http://mq.edu.au/policy/docs/academic_honesty/policy.html

New Assessment Policy in effect from Session 2 2016 http://mq.edu.au/policy/docs/assessment/policy_2016.html. For more information visit http://students.mq.edu.au/events/2016/07/19/new_assessment_policy_in_place_from_session_2/

Assessment Policy prior to Session 2 2016 http://mq.edu.au/policy/docs/assessment/policy.html

Grading Policy prior to Session 2 2016 http://mq.edu.au/policy/docs/grading/policy.html

Grade Appeal Policy http://mq.edu.au/policy/docs/gradeappeal/policy.html

Complaint Management Procedure for Students and Members of the Public http://www.mq.edu.au/policy/docs/complaint_management/procedure.html

Disruption to Studies Policy http://www.mq.edu.au/policy/docs/disruption_studies/policy.html *The Disruption to Studies Policy is effective from March 3 2014 and replaces the Special Consideration Policy.*

In addition, a number of other policies can be found in the Learning and Teaching Category of Policy Central.

Student Code of Conduct

Macquarie University students have a responsibility to be familiar with the Student Code of Conduct: https://students.mq.edu.au/support/student_conduct/

Results

Results shown in *iLearn*, or released directly by your Unit Convenor, are not confirmed as they are subject to final approval by the University. Once approved, final results will be sent to your student email address and will be made available in eStudent. For more information visit ask.mq.edu.au.

Student Support

Macquarie University provides a range of support services for students. For details, visit http://students.mq.edu.au/support/

Learning Skills

Learning Skills (mq.edu.au/learningskills) provides academic writing resources and study strategies to improve your marks and take control of your study.

- Workshops
- StudyWise
- Academic Integrity Module for Students
- Ask a Learning Adviser

Student Services and Support

Students with a disability are encouraged to contact the Disability Service who can provide appropriate help with any issues that arise during their studies.

Student Enquiries

For all student enquiries, visit Student Connect at ask.mq.edu.au

IT Help

For help with University computer systems and technology, visit http://www.mq.edu.au/about_us/offices_and_units/information_technology/help/.

When using the University's IT, you must adhere to the Acceptable Use of IT Resources Policy. The policy applies to all who connect to the MQ network including students.

Graduate Capabilities

Creative and Innovative

Our graduates will also be capable of creative thinking and of creating knowledge. They will be imaginative and open to experience and capable of innovation at work and in the community. We want them to be engaged in applying their critical, creative thinking.

This graduate capability is supported by:

Learning outcomes

- You should understand and be able to describe mathematically the fundamental physics underpinning optical fields in waveguides. You should be able to explain the role and mathematics of optical waveguide modes and derive and apply dispersion relations for simple waveguide geometries.
- You should have an operational capability to use optical detectors, diagnostics and measurement instruments, and an understanding of the physics of various optoelectronic phenomena. You should have confidence and capability to use and operate key optical diagnostic equipment.

Assessment tasks

- Assignments
- Laboratory reports
- Final Examination

Capable of Professional and Personal Judgement and Initiative

We want our graduates to have emotional intelligence and sound interpersonal skills and to demonstrate discernment and common sense in their professional and personal judgement. They will exercise initiative as needed. They will be capable of risk assessment, and be able to handle ambiguity and complexity, enabling them to be adaptable in diverse and changing environments.

This graduate capability is supported by:

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Commitment to Continuous Learning

Our graduates will have enquiring minds and a literate curiosity which will lead them to pursue knowledge for its own sake. They will continue to pursue learning in their careers and as they participate in the world. They will be capable of reflecting on their experiences and relationships with others and the environment, learning from them, and growing - personally, professionally and socially.

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Assessment tasks

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Discipline Specific Knowledge and Skills

Our graduates will take with them the intellectual development, depth and breadth of knowledge, scholarly understanding, and specific subject content in their chosen fields to make them competent and confident in their subject or profession. They will be able to demonstrate, where relevant, professional technical competence and meet professional standards. They will be able to articulate the structure of knowledge of their discipline, be able to adapt discipline-specific knowledge to novel situations, and be able to contribute from their discipline to inter-disciplinary solutions to problems.

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Critical, Analytical and Integrative Thinking

We want our graduates to be capable of reasoning, questioning and analysing, and to integrate and synthesise learning and knowledge from a range of sources and environments; to be able to critique constraints, assumptions and limitations; to be able to think independently and systemically in relation to scholarly activity, in the workplace, and in the world. We want them to have a level of scientific and information technology literacy.

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Problem Solving and Research Capability

Our graduates should be capable of researching; of analysing, and interpreting and assessing data and information in various forms; of drawing connections across fields of knowledge; and they should be able to relate their knowledge to complex situations at work or in the world, in order to diagnose and solve problems. We want them to have the confidence to take the initiative in doing so, within an awareness of their own limitations.

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- Final Examination

Effective Communication

We want to develop in our students the ability to communicate and convey their views in forms effective with different audiences. We want our graduates to take with them the capability to read, listen, question, gather and evaluate information resources in a variety of formats, assess, write clearly, speak effectively, and to use visual communication and communication technologies as appropriate.

This graduate capability is supported by:

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Engaged and Ethical Local and Global citizens

As local citizens our graduates will be aware of indigenous perspectives and of the nation's historical context. They will be engaged with the challenges of contemporary society and with knowledge and ideas. We want our graduates to have respect for diversity, to be open-minded, sensitive to others and inclusive, and to be open to other cultures and perspectives: they should have a level of cultural literacy. Our graduates should be aware of disadvantage and social justice, and be willing to participate to help create a wiser and better society.

This graduate capability is supported by:

Learning outcome

- You should have an operational capability to use optical detectors, diagnostics and measurement instruments, and an understanding of the physics of various optoelectronic phenomena. You should have confidence and capability to use and operate key optical diagnostic equipment.

Assessment task

- Laboratory reports

Socially and Environmentally Active and Responsible

We want our graduates to be aware of and have respect for self and others; to be able to work with others as a leader and a team player; to have a sense of connectedness with others and country; and to have a sense of mutual obligation. Our graduates should be informed and active participants in moving society towards sustainability.

This graduate capability is supported by:

Learning outcome

- You should have an operational capability to use optical detectors, diagnostics and measurement instruments, and an understanding of the physics of various optoelectronic phenomena. You should have confidence and capability to use and operate key optical diagnostic equipment.

Assessment task

- Laboratory reports

Changes since First Published

Date	Description
26/02/2016	Minor edits for formatting
26/02/2016	Addition of missing lecturer