PHYS7906

Advanced Photonics

Session 2, In person-scheduled-weekday, North Ryde 2024

School of Mathematical and Physical Sciences

Contents

General Information

Unit convenor and teaching staff
Lecturer and unit convener
Judith Dawes
judith.dawes@mq.edu.au

Lecturer
Rich Mildren
rich.mildren@mq.edu.au

Laboratory Officer
Gina Dunford
regina.dunford@mq.edu.au

Credit points
10

Prerequisites
Admission to MRes

Corequisites

Co-badged status

Unit description
The photonics revolution that followed the invention of the laser and low-loss optical fibres has impacted our society in a truly profound way. In concert with silicon electronics it is the core technology enabling the Internet, yet its existence and function is invisible to most individuals using modern communications. In this unit, we conduct a theoretical survey of some of the key physics and technologies that make up modern photonics and optical science. Topics can be adjusted to fit the interests of the cohort but are drawn from areas such as ray and wave treatments of light, propagation in single and multi-mode optical fibres, waveguide dispersion, nonlinear optics, properties of optical materials, optical devices such as lasers and detectors, laser processing of materials, nano-photonics and artificial materials, microscopy, and molecular spectroscopy. While we take a rigorous approach to the theory (largely expressed in Maxwell's theory of electromagnetism with elements of quantum physics where required,) we continually highlight the technology drivers and implications of the theory. The unit includes a substantial (20-25 hours) experimental component to develop photonics laboratory skills and familiarity with a range of optical devices and instruments encountered in photonics research.

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:

ULO1: demonstrate a comprehensive knowledge of optical materials and their use in linear optics.

ULO2: discuss a range of research principles and methods in photonics.

ULO3: describe the principles and methods for advanced photonics topics such as laser structuring of materials and applications.

ULO4: explain the origin of optical nonlinearities and be able to manipulate and interpret the mathematical descriptions of nonlinear phenomena.

ULO5: apply advanced optical techniques and concepts in a photonics laboratory environment, including planning and execution of experiments, performing appropriate quantitative analysis and reflection to provide a sophisticated scientific response to one or more physics questions, and the preparation of written or other reports to communicate these results.

General Assessment Information

The assessment for the unit is composed of four take-home problem sets, exercises in the laboratory and the final examination.

Assignments (30%)

Four assignments of problem sets will be set and marked for assessment purposes and issued approximately once every three weeks. Problems may be a mix of analytic derivations, calculations, computer coding and/or use of computational modelling tools. Worked solutions will be provided to problem sets after the due date. These problem sets are excellent preparation for the final examination, and we find that students who engage with the problem-solving tasks do well in the unit overall.

Academic integrity

Informal group discussion regarding the material connected to problem-set questions is encouraged, but **each student must independently develop and write up their own solutions**. Do not hesitate to seek help from the teaching team if you are having difficulties with the assigned problems. Breaches of the academic integrity policy may lead to sanctions that may include, but are not limited to, award of a failure grade for the unit and/or temporary suspension from studies. In cases determined by law, the University has a legal obligation to disclose the applied sanctions to outside parties, including certain employers.

Extensions

Extension for the assignments may be requested **well in advance** with justification.

Laboratory task (30%)

Laboratory sessions (2-3 hours) will be held weekly and a mix of experimental and computational work will be offered.

Assessment will be by a laboratory notebook, in the style of a professional scientist or engineer. The notebooks should include brief summaries of the purpose of the experiments, details of equipment used, measurements taken, error analysis, plots and brief conclusions. The intended audience is your peers within a research group.

Final examination (40%)

A 2 hour end-of-session exam will be held in the University Examination Period. Permitted materials will be advised in advance. You should present yourself for the final examination at the time and place designated in the University examination timetable. The timetable will be available in draft form approximately eight weeks before the commencement of examinations and in final form approximately four weeks before the commencement of examinations. If you receive special consideration for the final exam, a supplementary exam will be scheduled during the supplementary exam period. By making a special consideration application for the final exam you are declaring yourself available for a resit during the supplementary examination period and will not be eligible for a second special consideration approval based on pre-existing commitments. Please ensure you are familiar with the policy prior to submitting an application. Approved applicants will receive a notification one week before the exam with the exact date and time of their supplementary examination.

Late Assessment Submission Penalty

From 1 July 2022, Students enrolled in Session-based units with written assessments will have the following late penalty applied. Please see https://students.mq.edu.au/study/assessment-exams/assessments for more information.

Unless a Special Consideration request has been submitted and approved, a 5% penalty (of the total possible mark) will be applied each day a written assessment is not submitted, up until the 7th day (including weekends). After the 7th day, a grade of '0' will be awarded even if the assessment is submitted. Submission time for all written assessments is set at **11:55 pm**.
A one hour grace period is provided to students who experience a technical concern.

Assessments where Late Submissions will be accepted

In this unit, late submissions will accepted as follows:

-
  - Assignments: Yes, standard late penalty applies
  - Lab exercises: Yes, standard late penalty applies
  - Exam: Not relevant.

Assessment Tasks

Name	Weighting	Hurdle	Due
Assignments	30%	No	week 3, 6, 9, 12
Lab report	30%	No	week 7 and week 13
Final exam	40%	No	formal examination period

Assignments

Assessment Type [1]: Problem set
Indicative Time on Task [2]: 24 hours
Due: **week 3, 6, 9, 12**
Weighting: **30%**

A number (3-6) of problem-based assignments throughout the session.

On successful completion you will be able to:

- demonstrate a comprehensive knowledge of optical materials and their use in linear optics.
- discuss a range of research principles and methods in photonics.
- describe the principles and methods for advanced photonics topics such as laser structuring of materials and applications.
- explain the origin of optical nonlinearities and be able to manipulate and interpret the mathematical descriptions of nonlinear phenomena.

Lab report

Assessment Type [1]: Lab report
Indicative Time on Task [2]: 12 hours
Due: **week 7 and week 13**
Weighting: **30%**

Report of the planning, execution and analysis of a laboratory-based photonics investigation. This may take multiple forms involving both written material and in-person presentation.

On successful completion you will be able to:

- demonstrate a comprehensive knowledge of optical materials and their use in linear optics.
- discuss a range of research principles and methods in photonics.
- describe the principles and methods for advanced photonics topics such as laser structuring of materials and applications.
- explain the origin of optical nonlinearities and be able to manipulate and interpret the mathematical descriptions of nonlinear phenomena.
- apply advanced optical techniques and concepts in a photonics laboratory environment, including planning and execution of experiments, performing appropriate quantitative analysis and reflection to provide a sophisticated scientific response to one or more physics questions, and the preparation of written or other reports to communicate these results.

Final exam

Assessment Type [1]: Examination
Indicative Time on Task [2]: 20 hours
Due: **formal examination period**
Weighting: **40%**

Exam in the University Examination period, covering the entire content of the unit.

On successful completion you will be able to:

- demonstrate a comprehensive knowledge of optical materials and their use in linear optics.
- discuss a range of research principles and methods in photonics.
- describe the principles and methods for advanced photonics topics such as laser structuring of materials and applications.
- explain the origin of optical nonlinearities and be able to manipulate and interpret the mathematical descriptions of nonlinear phenomena.

---

[1] If you need help with your assignment, please contact:

- the academic teaching staff in your unit for guidance in understanding or completing this type of assessment
- the Writing Centre for academic skills support.

[2] Indicative time-on-task is an estimate of the time required for completion of the assessment task and is subject to individual variation

Delivery and Resources

Content

We will take a survey approach, selecting topics from the following list:

- Properties of light
- Atomic transitions
- Laser theory and rate equations
- Optical resonators
- Q-switching and mode-locking
- Theory of ray optics and Gaussian beams
- Maxwell's equations and the wave equation
- Optical waveguides and propagation
- Anisotropic media
- Introduction to nonlinear optics
- Optical communications
- Molecular spectroscopy
- Laser spectroscopy
- Frequency combs

Delivery

With a small class, we will adopt a mix of discussion-style workshops and lab sessions, and home reading.

Policies and Procedures

Macquarie University policies and procedures are accessible from Policy Central (https://policies.mq.edu.au). Students should be aware of the following policies in particular with regard to Learning and Teaching:

- Academic Appeals Policy
- Academic Integrity Policy
- Academic Progression Policy
- Assessment Policy
- Fitness to Practice Procedure
- Assessment Procedure
- Complaints Resolution Procedure for Students and Members of the Public

- Special Consideration Policy

Students seeking more policy resources can visit Student Policies (https://students.mq.edu.au/support/study/policies). It is your one-stop-shop for the key policies you need to know about throughout your undergraduate student journey.

To find other policies relating to Teaching and Learning, visit Policy Central (https://policies.mq.edu.au) and use the search tool.

Student Code of Conduct

Macquarie University students have a responsibility to be familiar with the Student Code of Conduct: https://students.mq.edu.au/admin/other-resources/student-conduct

Results

Results published on platform other than eStudent, (eg. iLearn, Coursera etc.) 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 connect.mq.edu.au or if you are a Global MBA student contact globalmba.support@mq.edu.au

Academic Integrity

At Macquarie, we believe academic integrity – honesty, respect, trust, responsibility, fairness and courage – is at the core of learning, teaching and research. We recognise that meeting the expectations required to complete your assessments can be challenging. So, we offer you a range of resources and services to help you reach your potential, including free online writing and maths support, academic skills development and wellbeing consultations.

Student Support

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

The Writing Centre

The Writing Centre provides resources to develop your English language proficiency, academic writing, and communication skills.

- Workshops
- Chat with a WriteWISE peer writing leader
- Access StudyWISE
- Upload an assignment to Studiosity
- Complete the Academic Integrity Module

The Library provides online and face to face support to help you find and use relevant information resources.

- Subject and Research Guides

- Ask a Librarian

Student Services and Support

Macquarie University offers a range of Student Support Services including:

- IT Support
- Accessibility and disability support with study
- Mental health support
- Safety support to respond to bullying, harassment, sexual harassment and sexual assault
- Social support including information about finances, tenancy and legal issues
- Student Advocacy provides independent advice on MQ policies, procedures, and processes

Student Enquiries

Got a question? Ask us via the Service Connect Portal, or contact Service Connect.

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.

Changes from Previous Offering

New staff teaching the unit, and changes to both experimental and theoretical content.

Unit information based on version 2024.01R of the Handbook