PHYS7906

Advanced Photonics

Session 2, In person-scheduled-weekday, North Ryde 2022

School of Mathematical and Physical Sciences

Contents

General Information

Unit convenor and teaching staff
Convenor and instructor
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Credit points
10

Prerequisites
Admission to MRes

Corequisites

Co-badged status

Unit description
We explore the origin of nonlinear optical effects, and how they are used in modern optics to convert and control light. We derive the hierarchy of nonlinear effects, such as simple frequency doubling and mixing and enhancement using periodic materials; the Kerr effect and its applications in ultrafast lasers; Raman scattering and Brillouin scattering and their relevance to all-optical switching; and high-harmonic generation for generating XUV light and attosecond pulses. Advanced topics may include using the nonlinear Schrodinger equation to investigate nonlinear effects in fibres, such as soliton formation, super continuum generation.

We establish how to use light-matter interactions to detect and study atoms and molecules. We determine the form of their excitation spectra, the factors that determine the shape and width of the spectral features, and how to measure them using infrared to ultraviolet excitation wavelengths. We will study more complex techniques that may include enhancements such as cavity ring down and Doppler-free methods; Raman spectroscopy and techniques such as CARS; and enhancement of Raman scattering using nanostructures and the quest for single molecule detection.

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 manipulate and interpret the mathematical descriptions of nonlinear phenomena.

ULO5: apply advanced microscopy concepts in a laboratory environment, including detailed planning of experiments, performing the requisite analysis to provide tangible answers to posed research questions, and the preparation of reports to communicate these results.

General Assessment Information

The assessment for the unit is composed of fortnightly take-home problem sets, exercises in the computational 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 our strong experience is 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 lecturing team if you are having difficulties with the assigned problems. All students must comply with the academic integrity policy by preparing and submitting their answers independently. To ensure compliance interviews with selected students may be conducted where there is undue similarity in submitted solutions.

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 form 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 a suitable justification. No extensions to the assignment due dates will be granted within 48 hours of the original due date.

Laboratory task (30%)

There will be approximately 6 laboratory tasks of about 2 hours duration, mostly experimental, some potentially computational.

Assessment will be on the basis of an electronic laboratory notebook, in the style of a professional photonics scientest or engineer. The notebooks should include brief summaries of the purpose of each experiment, details of equipment used, measurements taken, error analysis, plots and brief conclusions. The intended audience would be your peers within a research or measurement group.

Final examination (40%)

There will be a 2 hour end-of-session exam to be held in the University Examination Period.

Permitted materials will be advised in advance.

You are expected to present yourself for the final examination at the time and place designated in the University examination timetable (https://iexams.mq.edu.au/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 an individual notification one week prior to 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 1-hour grace period is provided to students who experience a technical concern.

For any late submission of time-sensitive tasks, such as scheduled tests/exams, performance assessments/presentations, and/or scheduled practical assessments/labs, students need to submit an application for Special Consideration.

Assessments where Late Submissions will be accepted

In this unit, late submissions will accepted as follows:

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

Assessment Tasks

Name	Weighting	Hurdle	Due
Lab report	30%	No	Approximately every 2 weeks
Assignments	30%	No	Approximately every 3 weeks
Final exam	40%	No	Scheduled during the normal exam period

Lab report

Assessment Type [1]: Lab report
Indicative Time on Task [2]: 12 hours
Due: **Approximately every 2 weeks**
Weighting: **30%**

Report of the planning, execution and analysis of a lab-based microscopy investigation.

On successful completion you will be able to:

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- 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 manipulate and interpret the mathematical descriptions of nonlinear phenomena.
- apply advanced microscopy concepts in a laboratory environment, including detailed planning of experiments, performing the requisite analysis to provide tangible answers to posed research questions, and the preparation of reports to communicate these results.

Assignments

Assessment Type [1]: Problem set
Indicative Time on Task [2]: 24 hours
Due: **Approximately every 3 weeks**
Weighting: **30%**

Four 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 manipulate and interpret the mathematical descriptions of nonlinear phenomena.

Final exam

Assessment Type [1]: Examination
Indicative Time on Task [2]: 20 hours
Due: **Scheduled during the normal exam 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 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

About the content

We will take a survey approach covering a selection of topics from the following:

- elementary properties of light
- the theory of ray optics
- Maxwell's equations and the wave equation
- optical waveguides and propagation
- anisotropic materials
- nonlinear optics
- optical communications
- molecular spectroscopy

Delivery

With a very small class, we will adopt a mix of discussion-style meetings and lectorials, student-led discussions, 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/su

pport/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 ask.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 Enquiries

Got a question? Ask us via AskMQ, 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.