# PHYS306

## Optical Physics

S2 Day 2019

*Dept of Physics and Astronomy*

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# General Information

Unit convenor and teaching staff

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Credit points
3

Prerequisites
PHYS301

Corequisites

Co-badged status
Phys799 MRes Shell Unit

Unit description
Optics touches on many branches of physics and technology in the world today. The theme of this unit is physical optics, understanding how interference and diffraction determine how light propagates and interacts with optical systems. Interference leads to devices such as the Fabry-Perot interferometer, and multilayer dielectric filters; diffraction leads to new ways of analysing beam propagation and image formation. The mode theory of light propagation in free space and optical waveguides is developed and applied to lasers and fibre optics. Key optical methods are studied in the regular laboratory program together with advanced data analysis techniques and report writing providing a strong foundation for future research project work.

## 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:

Apply theoretical concepts underpinning central topics in optics - from the progression of Maxwell's equations into geometrical optics, optical coatings, polarization, anisotropic media and nonlinear effects - to common scenarios in experimental optics.

Apply theoretical concepts in interference, diffraction and Fourier optics, to common scenarios in experimental optics.

Use these theoretical concepts and foundations to analyse and interpret recent examples of applied optics research.

Ability to understand one or more topics in contemporary optics and effectively communicate these to an audience.

In the laboratory context, attain a sophisticated level of experimental skill including understanding advanced experimental methods, carrying out measurements with appropriate analysis and the preparation of detailed reports.

# General Assessment Information

This unit has hurdle requirements, specifying a minimum standard that must be attained. To pass this unit you must obtain a mark of at least 50% in the unit overall, as well as a 40% hurdle requirement in the final examination, lab reports and lab logbook.

# Assessment Tasks

| Name | Weighting | Hurdle | Due |
|---|---|---|---|
| Assignments | 15% | No | various |
| Laboratory Reports | 20% | Yes | various |
| Laboratory Logbook | 10% | Yes | Mon 5pm Wk 13 |
| Presentation | 5% | Yes | Thu, 1-4pm, Week 10 |
| Final Exam | 50% | Yes | End of Unit |

## Assignments

Due: **various**
Weighting: **15%**

There will be 6 assignments with equal weight, three from each part of the course. Assignments will be issued on Wednesday of Wks 1, 3, 5, 7, 9, 11, and will be due 12 days (Mon 5pm) later.

We encourage students to use feedback from Assignment 1 and/or within lectures to discuss any issues relating to continuation beyond the Census Date.

Extension Requests

Given the importance placed on assignments as a key aid to learning, we expect assignments to be submitted on time. In turn, we undertake to return your assignments (provided they were submitted on time), marked and with feedback within two weeks of their due date. This will allow us to provide you feedback in time to aid your ongoing learning through the course. Extensions will only be considered if requested with valid reasons prior to the due date. Work submitted after the due date without an approved extension will accrue a penalty of 10% per additional day for the first week. Work submitted more than one week late will be marked at the lecturer's discretion.

On successful completion you will be able to:

- Apply theoretical concepts underpinning central topics in optics - from the progression of Maxwell's equations into geometrical optics, optical coatings, polarization, anisotropic media and nonlinear effects - to common scenarios in experimental optics.
- Apply theoretical concepts in interference, diffraction and Fourier optics, to common scenarios in experimental optics.
- Use these theoretical concepts and foundations to analyse and interpret recent examples of applied optics research.
- Ability to understand one or more topics in contemporary optics and effectively

communicate these to an audience.

## Laboratory Reports

Due: **various**
Weighting: **20%**
**This is a hurdle assessment task (see assessment policy for more information on hurdle assessment tasks)**

Students must complete 4 experiments and submit two full reports and associated drafts together with their log book and calculations for the other two experiments. Submission of the 2 reports, and a logbook with a record of 4 experiments completed, and the associated calculations and analysis for the two experiments not the subject of a formal report, is mandatory.

**Reports**

- You should refer to the document “Recommendations for Laboratory Report Writing” when preparing reports.
- A draft report or report can only be submitted once a satisfactory sign off on your laboratory book record of the experiment has been obtained.
- Draft reports are optional but they represent an important opportunity to improve your report writing by gaining feedback during the writing stage. They will not be formally assessed. They will be returned to you annotated with suggestions for improvement which you should act on in your final report submitted for assessment.
- Any report submitted after a draft phase must submit the original draft with the report.
- Draft reports will be returned no later than one week after submission. Reports for assessment will be returned no later than two weeks after submission.
- Photocopies of all relevant pages for the experiment from your log-book should be submitted with your draft and/or report.
- Submissions should be to Dr Gina Dunford in the third year laboratory by the due date.

**Submission Dates**

1. Draft first report – 1pm Wed, Week 5
2. First report – 1pm Wed, Week 7
3. Draft second report – 1pm Wed, Week 10
4. Second report – 1pm Wed, Week 12

Assessment of full reports will be graded according to its conformity to the report Recommendations (see above). The marking scheme will have separate components for Abstract/Conclusions, Introduction, Experiment Description (Methods), Results, Analysis and Discussion, and Overall Presentation.

**Satisfactory completion of the laboratory assessment is a hurdle task.** You must achieve at least 40% in each of the two assessed tasks to pass the unit. If you fail to reach this mark, you must arrange to retake that assessment item, after discussion with the marker.

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- Apply theoretical concepts in interference, diffraction and Fourier optics, to common scenarios in experimental optics.
- Use these theoretical concepts and foundations to analyse and interpret recent examples of applied optics research.
- Ability to understand one or more topics in contemporary optics and effectively communicate these to an audience.
- In the laboratory context, attain a sophisticated level of experimental skill including understanding advanced experimental methods, carrying out measurements with appropriate analysis and the preparation of detailed reports.

## Laboratory Logbook

Due: **Mon 5pm Wk 13**
Weighting: **10%**
**This is a hurdle assessment task (see assessment policy for more information on hurdle assessment tasks)**

Logbooks with the record of experimental data are to be kept and submitted by the above due date. The marking criteria are readability, layout, completeness and clarity.

Your submitted laboratory logbook is to include the write-up of all four experiments with graphs, analysis and calculations. The logbook should not have the formal background and polished presentation of a formal report. It should contain all recorded data and your analysis of measurements, as well as your conclusions. It should provide sufficient information for a reader to assess the validity of your experimental procedure and conclusions.

On successful completion you will be able to:

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- Use these theoretical concepts and foundations to analyse and interpret recent

examples of applied optics research.
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## Presentation

Due: **Thu, 1-4pm, Week 10**
Weighting: **5%**
**This is a hurdle assessment task (see assessment policy for more information on hurdle assessment tasks)**

In Week 10, students will provide a short presentation based on one of their laboratory experiments. This will be held in the usual laboratory times-slot. Presentations should aim to:

1. Describe the physics principles that underpin the experiment;
2. What findings were achieved;
3. How these principles have been applied or adapted in recent research.

Students may work alone or in pairs and will have seven minutes per student for the presentation. Assessment will be based on the clarity and effectiveness of presentation, your explanation of the essential physics in your chosen area, and your discussion of why this area is significant.

You may use aids such as PowerPoint or overhead transparencies but this is not required. Some of the most effective presentations use nothing more than the whiteboard. We are more interested in seeing how you can be creative and effective in your communication, than the degree to which you have mastered fancy software tricks. Further details on requirements and assessment will be provided during the semester.

The presentation will be assessed (out of 30) according to the three areas of Scientific Accuracy, Content and Depth, and Style (with equal weighting).

On successful completion you will be able to:
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- Use these theoretical concepts and foundations to analyse and interpret recent examples of applied optics research.

- Ability to understand one or more topics in contemporary optics and effectively communicate these to an audience.

## Final Exam

Due: **End of Unit**
Weighting: **50%**
**This is a hurdle assessment task (see assessment policy for more information on hurdle assessment tasks)**

The examination lasts 2 hours 30 minutes and consists of thirteen questions worth 4 marks each and six questions worth 8 marks each. All questions are to be answered. The exam questions will test knowledge across the material provided in the lectures and assignments only.

**The final examination is a hurdle requirement.** You must obtain a mark of at least 40% in the final exam to be eligible to pass the unit. If your mark in the final examination is between 30% and 39% inclusive, you will be a given a second and final chance to attain the required level of performance. The mark awarded for the second exam towards your final unit mark will be capped at 40%.

*If you receive special consideration for the final exam, a supplementary exam will be scheduled after results are released. Please see FSE101 in iLearn for dates. 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. Second chance exams for hurdle assessments will also be scheduled in this period.*

On successful completion you will be able to:

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- Use these theoretical concepts and foundations to analyse and interpret recent examples of applied optics research.
- Ability to understand one or more topics in contemporary optics and effectively communicate these to an audience.

# Delivery and Resources

## Required Text

Introduction to Optics (3rd Edition) by FL Pedrotti and LS Pedrotti (Prentice-Hall, 2007)

## Recommended Reading

- Optics by E Hecht (Addison-Wesley)
- Optical Physics (3rd Edition) by SG Lipson and H Lipson and DS Tannhauser (Cambridge University Press)
- The Fabry-Perot Interferometer by JM Vaughan (Adam Hilger)
- Interferometry by WH Steel (Cambridge University Press)
- Optical Holography by P Hariharan (Cambridge University Press)
- Optical Waves in Crystals by A Yariv and P Yeh (Wiley)

## Teaching Strategy

This unit is taught through lectures and tutorials and through undertaking laboratory experiments. We strongly encourage students to attend lectures because they provide a much more interactive and effective learning experience than studying a text book. Questions during and outside lectures are strongly encouraged in this unit – please do not be afraid to ask as it is likely that your classmates will also want to know the answer. You should aim to read the relevant sections of the textbook before and after lectures and discuss the content with classmates and lecturers.

This unit includes a compulsory experimental component. The experiments are stand alone investigations and may include topics not covered by the lecture content of this course – They are an important part of the learning for this unit and the skills learned are essential for a well rounded physics graduate.

You should aim to spend 3 hours per week working on the assignments. You may wish to discuss your assignment problems with other students and the lecturers, but you are required to hand in your own work (see the note on plagiarism below). Assignments are provided as one of the key learning activities for this unit, they are not there just for assessment. It is by applying knowledge learned from lectures and textbooks to solve problems that you are best able to test and develop your skills and understanding of the material.

# Unit Schedule

## Part I: EM propagation through complex media

- Electromagnetic waves in media
- Fresnel reflection coefficients
- Multi-layer optical coatings
- Gaussian beams
- Descriptions of polarisation states and control
- Anisotropic media
- Non-linear optics

## Part II: Coherent optics and interference

- Interference
- Fabry-Perot interferometer
- Fourier theory
- Diffraction theory
- Fourier optics
- Fraunhofer (far-field) diffraction
- Fresnel (near-field) diffraction
- Near field optics
- Spatial coherence
- Temporal coherence
- Holography

# Policies and Procedures

Macquarie University policies and procedures are accessible from Policy Central (https://staff.mq.edu.au/work/strategy-planning-and-governance/university-policies-and-procedures/policy-central). 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
- Grade Appeal Policy
- Complaint Management Procedure for Students and Members of the Public
- Special Consideration Policy *(**Note:** The Special Consideration Policy is effective from 4 December 2017 and replaces the Disruption to Studies Policy.)*

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

If you would like to see all the policies relevant to Learning and Teaching visit Policy Central (https://staff.mq.edu.au/work/strategy-planning-and-governance/university-policies-and-procedures/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/study/getting-started/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

# W.H."Beattie" Steel PRIZE

As a result of a generous donation to the University, the W H “Beattie” Steel Prize for Optical Physics may be awarded to the strongest student in the unit. We expect the value of the prize to be in the vicinity of $400.

Beattie Steel gained the highest French doctorate for his work on Fourier Transform methods at L’Institut d’Optique in Paris. He was President of the International Commission of Optics, author of “Interferometry” and a winner of the Mees Medal, given by the Optical Society of America. He led Optics research at CSIRO, Lindfield for 30 years and he continued this as an Honorary Professor at Macquarie University.

# 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

If you are a Global MBA student contact globalmba.support@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

- Apply theoretical concepts underpinning central topics in optics - from the progression of Maxwell's equations into geometrical optics, optical coatings, polarization, anisotropic media and nonlinear effects - to common scenarios in experimental optics.
- Apply theoretical concepts in interference, diffraction and Fourier optics, to common scenarios in experimental optics.
- Use these theoretical concepts and foundations to analyse and interpret recent examples of applied optics research.
- Ability to understand one or more topics in contemporary optics and effectively communicate these to an audience.
- In the laboratory context, attain a sophisticated level of experimental skill including understanding advanced experimental methods, carrying out measurements with appropriate analysis and the preparation of detailed reports.

### Assessment tasks

- Assignments
- Laboratory Reports
- Laboratory Logbook
- Presentation
- Final Exam

## 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:

## Learning outcomes

- Apply theoretical concepts underpinning central topics in optics - from the progression of Maxwell's equations into geometrical optics, optical coatings, polarization, anisotropic media and nonlinear effects - to common scenarios in experimental optics.
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- In the laboratory context, attain a sophisticated level of experimental skill including understanding advanced experimental methods, carrying out measurements with appropriate analysis and the preparation of detailed reports.

## Assessment tasks

- Laboratory Reports
- Presentation

# 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.

This graduate capability is supported by:

## Learning outcomes

- Apply theoretical concepts underpinning central topics in optics - from the progression of Maxwell's equations into geometrical optics, optical coatings, polarization, anisotropic media and nonlinear effects - to common scenarios in experimental optics.
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## Assessment tasks

- Assignments
- Laboratory Reports
- Laboratory Logbook
- Presentation
- Final Exam

# 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.

This graduate capability is supported by:

## Learning outcomes

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## Assessment tasks

- Assignments
- Laboratory Reports
- Laboratory Logbook

- Presentation
- Final Exam

## 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.

This graduate capability is supported by:

### Learning outcomes

- Apply theoretical concepts underpinning central topics in optics - from the progression of Maxwell's equations into geometrical optics, optical coatings, polarization, anisotropic media and nonlinear effects - to common scenarios in experimental optics.
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- In the laboratory context, attain a sophisticated level of experimental skill including understanding advanced experimental methods, carrying out measurements with appropriate analysis and the preparation of detailed reports.

### Assessment tasks

- Assignments
- Laboratory Reports
- Laboratory Logbook
- Presentation
- Final Exam

## 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.

This graduate capability is supported by:

## Learning outcomes

- Apply theoretical concepts underpinning central topics in optics - from the progression of Maxwell's equations into geometrical optics, optical coatings, polarization, anisotropic media and nonlinear effects - to common scenarios in experimental optics.
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- Use these theoretical concepts and foundations to analyse and interpret recent examples of applied optics research.
- In the laboratory context, attain a sophisticated level of experimental skill including understanding advanced experimental methods, carrying out measurements with appropriate analysis and the preparation of detailed reports.

## Assessment tasks

- Assignments
- Laboratory Reports
- Laboratory Logbook
- Presentation
- Final Exam

# 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:

## Learning outcomes

- Use these theoretical concepts and foundations to analyse and interpret recent examples of applied optics research.
- Ability to understand one or more topics in contemporary optics and effectively communicate these to an audience.
- In the laboratory context, attain a sophisticated level of experimental skill including understanding advanced experimental methods, carrying out measurements with appropriate analysis and the preparation of detailed reports.

## Assessment tasks

- Assignments

- Laboratory Reports
- Laboratory Logbook
- Presentation
- Final Exam

## 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

- Ability to understand one or more topics in contemporary optics and effectively communicate these to an audience.

### Assessment task

- Presentation

## 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

- Ability to understand one or more topics in contemporary optics and effectively communicate these to an audience.

### Assessment task

- Presentation

# Laboratory

## Required work

You must attend the scheduled laboratory session each week from Week 1 to Week 12. Access to the laboratory at other times will not normally be possible due to staffing constraints. You are urged to finish one experiment at a time, aiming to take no more than three laboratory sessions.

Students must complete 4 experiments and submit two full reports and associated drafts together with their laboratory logbook and calculations for the other two experiments. Submission of the 2 reports, and a logbook with a record of 4 experiments completed, and the associated calculations and analysis for the two experiments not the subject of a formal report, is mandatory. **The logbook in the laboratory class must be updated at each attendance**. Students writing experimental results onto loose sheets of paper will have these confiscated in the laboratory. Data etc. collected in electronic formats must be reproduced in hardcopy in the logbook. This original record is the logbook that must be submitted for assessment.

We expect to mark and return laboratory reports submitted on time, within two weeks at most.

## Available Experiments

- Correlation Interferometer
- Diffraction and Image Formation
- Fabry-Perot Interferometer
- Q-switched Nd:YAG Laser
- Photon Counting
- Polarised Light and Berry Phase

## Safety

A condition of entry to the laboratory is a thorough knowledge of the safety requirements in the laboratory, given in the document entitled "Health and Safety Guidelines in the 300 Level Physics Laboratory". Students will be issued with the document in week 2 and will complete a short written quiz to demonstrate their understanding of safety requirements observed during all laboratory sessions. The safety aspects of the laboratory can also be found on posters in the laboratory.

## General notes

- The laboratory sessions start in the **first** week of the semester.
- You must sign in and out using the Attendance Book (your name, date and experiment, legibly).
- Students should make a booking for three laboratory afternoons for each experiment they undertake. A booking gives priority provided the students arrive punctually at the start of the laboratory session.
- Logbooks with the record of experimental data are to be kept. These will be assessed with criteria for readability, layout, completeness and clarity. A student must gain a satisfactory sign-off in their experimental log-book before any draft or report submission can be made.

# Changes since First Published

| Date | Description |
|---|---|
| 28/08/2019 | Updated with minor mods to the due dates for lab reports. |
| 22/07/2019 | It was intended to start labs in Wk 1 to help reduce workload at end of semester. This has now been corrected. |