PHYS301

Electromagnetism and Quantum Physics

S1 Day 2014

Physics and Astronomy

Contents

General Information

Unit convenor and teaching staff
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Credit points
3

Prerequisites
PHYS201(P) and PHYS202(P)

Corequisites
MATH235

Co-badged status

Unit description

The first part of this unit deals with the classical theory of electromagnetism, which is the first successful unified theory in physics. This is an extension of the work covered in PHYS202. The theory offers solutions to an enormous range of problems in electromagnetism and optics from research to industry. Topics include: special techniques for calculating potentials; scalar and vector potentials; Maxwell's equations for electrodynamics; energy and momentum in electrodynamics (Poynting's theorem); electromagnetic waves in vacuum and materials; and the generation of electromagnetic radiation. The second part deals with the fascinating world of quantum physics, providing a modern introduction to quantum mechanics. As well as being the theory that underlies most of modern physics, it also provides a viewpoint about the nature of the physical world that is completely at odds with our familiar concepts. The material covered here aims to provide an introduction to the basic ideas of quantum mechanics and the mathematical language that is needed to describe the new physics it contains. Extensive laboratory work covering both electromagnetism and quantum physics is a core activity, giving students the opportunity to explore experimental physics using a wide variety of measurement techniques and equipment.

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:

- Acquisition of an understanding of the mathematical formalism of classical electromagnetism
- Experience in the use of knowledge of mathematical formalism to explain fundamental concepts and phenomena in electromagnetism
- An understanding of the link between the underlying theory of electromagnetism, and everyday phenomena, as well as scientific and engineering applications
- Acquisition of an understanding of the mathematical formalism of quantum mechanics and the physical motivations behind this formalism
- Experience in applying this knowledge to solve a range of basic problems in modern quantum theory
- Experience in investigating various physical phenomena experimentally, including performing measurements, analysing the data obtained, and writing detailed reports on these investigations

Assessment Tasks

Name	Weighting	Due
Assignments	10%	See Unit Schedule
Laboratory reports	20%	See Unit Schedule
Laboratory logbook	10%	See Unit Schedule
Final Examination	60%	University Examination Period

Assignments

Due: **See Unit Schedule**
Weighting: **10%**

As for all physics units, problem solving is an essential aid to understanding the physical concepts involved and the mathematical tools that must be used. Regular assignments will be set and the problems marked and returned within two weeks. There will be three assignments in quantum mechanics and two in electromagnetism. The assessment of the electromagnetism computer laboratories will count as the equivalent of one assignment. Together the assignments and worksheets count as 10% of the final assessment. The assignment record will be used when considering requests for special consideration. Informal group discussion regarding the assignment problems is encouraged, but students should present their own solutions and should explicitly acknowledge those they have worked with on the assignment. You should also note that the examination in general contains material related to the assignment work.

All marking is performed according to principles of standards-based assessment. Marks are awarded for evidence of correct understanding and analysis of problems. Marks are not normalized to any set distribution.

300-level students should not need to be reminded that working on problems is an essential part of any physics course. It is only by attempting problems that an understanding of new (and sometimes strange) concepts is obtained. Do not hesitate to seek help if you are having difficulties with the assignment problems.

Extension Requests: Given the importance we place 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**.

If for any reason a student is unable to submit an assignment by the due date, the student should contact the relevant staff member as soon as possible, explain the situation, and request an extension. If such contact is not made, then the student will be penalised 20% for each working day that the assignment is late (ie an assignment due on a Friday and handed in on a

Monday is penalised as if it is one day late). As complete solutions for an assignment are usually handed out to the class a week after the assignment is due, an extension beyond a week is generally not possible, and in any case would receive a grade of zero.

On successful completion you will be able to:

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- Experience in the use of knowledge of mathematical formalism to explain fundamental concepts and phenomena in electromagnetism
- An understanding of the link between the underlying theory of electromagnetism, and everyday phenomena, as well as scientific and engineering applications
- Acquisition of an understanding of the mathematical formalism of quantum mechanics and the physical motivations behind this formalism
- Experience in applying this knowledge to solve a range of basic problems in modern quantum theory

Laboratory reports

Due: **See Unit Schedule**
Weighting: **20%**

Labs start in the first week of term. You are required to carry out at least four experiments, each taking no more than three weeks to complete, submitting reports on two of them according to the lab timetable (see 'Unit Schedule' in this Guide). These dates are not negotiable except in cases of serious illness or misadventure. A late penalty may otherwise be imposed.

Submitting your Report

The experiments currently available are:

Group 1: Electromagnetism Experiments

- Transmission Lines
- Microwaves
- Microstrip
- Noise

Group 2: Atomic (Quantum) & Solid State Physics Experiments

- Debye Temperature
- X-ray Diffraction
- Properties of Semiconductors
- Magnetic Susceptibility
- NMR and ESR

- Zeeman Effect

Please note the following points

1. You are required to complete at least one experiment from Group 1. Your other three experiments may be chosen from any on the list.
2. 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.
3. Available for each project is a resource folder containing useful background information. These may be taken away from the lab, but must be returned within three weeks for other students to use.
4. You are required to submit a first draft report by the deadline given above (see 'Unit Schedule'). This will be carefully reviewed and returned to you with corrections and feedback to enable you to make necessary changes to produce a final polished version to resubmit for grading. This **compulsory submission of a first draft** is a necessary part of acquiring the skills for constructing a professional scientific report.
5. You should refer to the document *Recommendations for Laboratory Report Writing* when preparing reports. Please ensure that your reports conform to these guidelines, and feel free to discuss this with any of the staff.
6. Reports should not contain text that has been cut and pasted from the instructional notes. You should provide background and discussion material in your own words. It is preferred that you produce your own original figures, either hand-drawn or computer generated. Anything taken from another source must be clearly acknowledged.
7. Draft reports will not be formally assessed. They will be returned to you annotated with suggestions for improvements, which you should act on in your final report submitted for assessment.
8. Students gaining a mark of **8 out of 10 or better** in their first report assessment may choose to submit their second report in its final form in week 10 for assessment rather than as a draft. Students with a mark of 7 or less must submit a draft second report in week 10 and a final second report for assessment in week 12. Any student may choose to submit a draft second report if they want the opportunity to gain feedback before the submission of their second report for assessment. The report should be clearly marked "DRAFT" if pre-assessment feedback is being sought.
9. When you submit your final report after a draft phase **you must attach the original draft to it**.
10. Photocopies of all relevant pages for the experiment from your log-book must be

attached to your draft and/or final report.

11. Submissions should be to Dr Gina Dunford by 4:00pm on the due dates listed in the Unit Schedule. Please place your work under the door if the room is not occupied.

On successful completion you will be able to:

- Experience in the use of knowledge of mathematical formalism to explain fundamental concepts and phenomena in electromagnetism
- An understanding of the link between the underlying theory of electromagnetism, and everyday phenomena, as well as scientific and engineering applications
- Experience in investigating various physical phenomena experimentally, including performing measurements, analysing the data obtained, and writing detailed reports on these investigations

Laboratory logbook

Due: **See Unit Schedule**
Weighting: **10%**

Logbooks with the record of experimental data are to be kept, and will be assessed. Even if you choose not to write up a full report on an experiment your logbook must nevertheless include relevant calculations and graphs for each experiment. **Raw results with no analysis are not acceptable, and so will not meet the satisfactory standard for unit assessment.**

Logbooks will be assessed for readability, layout, completeness and clarity.

You are required to attach to each submitted report photocopies of the relevant pages from your lab logbook.

Your complete lab logbook must be submitted with your final report.

On successful completion you will be able to:

- Experience in investigating various physical phenomena experimentally, including performing measurements, analysing the data obtained, and writing detailed reports on these investigations

Final Examination

Due: **University Examination Period**
Weighting: **60%**

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.

You are expected to present yourself for the final examination at the time and place designated in the University examination timetable (http://www.timetables.mq.edu.au/exam/). 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.

On successful completion you will be able to:

- Acquisition of an understanding of the mathematical formalism of classical electromagnetism
- Experience in the use of knowledge of mathematical formalism to explain fundamental concepts and phenomena in electromagnetism
- An understanding of the link between the underlying theory of electromagnetism, and everyday phenomena, as well as scientific and engineering applications
- Acquisition of an understanding of the mathematical formalism of quantum mechanics and the physical motivations behind this formalism
- Experience in applying this knowledge to solve a range of basic problems in modern quantum theory

Delivery and Resources

Classes

Mixed Lecture and Tutorial/discussion

The timetable for classes can be found on the University web site at: http://www.timetables.mq.edu.au/

Laboratories will commence in the first week of semester. Students will be divided equally between the two sessions.

Required and Recommended Texts and/or Materials

Required Text

Electromagnetism: Introduction to Electrodynamics, DJ Griffiths, 3rd edition, Prentice-Hall, 1988

Quantum Mechanics: No textbook, however quantum physics lecture notes will be provided by Dr Cresser.

Recommended Readings

The Feynman Lectures on Physics, Vol II, Addison Wesley

The Feynman Lectures on Physics, Vol III, Addison Wesley

Technology Used and Required

Unit Web Page

This unit will be administered through iLearn at http://ilearn.mq.edu.au/course/view.php?id=349

9. Please check this site regularly for lecture and extension material available for downloading and look out for announcements. We will run one or more discussion fora through the iLearn page for both technical physics and administrative issues. Staff will ignore emails and discussion questions about issues which are already explained in this document or which have been covered in the announcements and discussion features of the iLearn page.

Teaching and Learning Strategy

The theoretical aspects of this unit are taught in lectures and tutorials with fortnightly assignments to strengthen the understanding of the material. The theoretical material is heavily mathematical in nature, and often abstract, and true understanding can only be achieved through testing and refining understanding through problem solving.

The experimental aspects of the unit require students to attend laboratories where they will be expected to set up experiments, take data, analyse the data within the context of the physical phenomena that are being studied, maintain a laboratory log-book, and report on their findings in clearly written laboratory reports.

Laboratory (Lab) Sessions

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

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

Lab Attendance

The laboratory sessions start in the first week of semester.

A condition of entry to the laboratory is thorough knowledge of the safety requirements in the laboratory. Students should revise these and they should be observed during all your lab sessions.

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.

Lab Safety

The laboratory sessions start in the first week of semester.

A condition of entry to the laboratory is thorough knowledge of the safety requirements in the laboratory. Students should revise these and they should be observed during all your lab. sessions.

You must sign in and out using the *Attendance Book* (your name, date and experiment, legibly).

Schedule of topics

Electromagnetism

Review of Maxwell's Equations and vector calculus

The scalar potential and properties of solutions to the Laplace equation

The vector potential

Potential formulation of Maxwell's equations

Energy and momentum in electromagnetism

Electromagnetic waves in vacuum, dielectrics and lossy media

Dipole radiation

Quantum Physics

Classical vs quantum mechanics

Wave/particle duality: the two slit experiment

The Stern-Gerlach experiment

Quantum states as vectors, superposition of states, measurement and randomness

Operations on states: unitary and Hermitean operators

Measurement and observables

Time evolution in quantum mechanics: the Schrödinger equation.

Changes since the last offering of this unit

- Computer lab sessions may be offered.

Unit Schedule

Schedule of assessable tasks and related materials

Assignments

The assignments will be handed out according to the following approximate timetable

Assignment No.	Date available on iLearn	Date due
1 EM	Friday March 7	Tuesday March 18
2 EM	Friday March 21	Tuesday April 1
3 EM	Friday April 4	Tuesday April 29
4 Quantum	Friday May 2	Tuesday May 13
5 Quantum	Friday May 16	Tuesday May 27
6 Quantum	Friday May 30	Tuesday June 10

We understand that at times due dates for assignments from several different units can collide and we are happy to accommodate changes in due dates, *provided the request occurs well in advance of the due date*.

Laboratory Work

You are required to carry out at least four experiments, each taking no more than three weeks to complete, submitting reports on two of them according to the following timetable. These dates are not negotiable except in cases of serious illness or misadventure. A late penalty may otherwise be imposed.

Draft 1st report	Tuesday 1 April	Week 5
Final submission 1st report	Tuesday 29 April	Week 7
Draft 2nd report	Tuesday 20 May	Week 10
Final submission 2nd report (including laboratory logbook)	Tuesday 3 June	Week 12

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

Assessment Policy http://mq.edu.au/policy/docs/assessment/policy.html

Grading Policy http://mq.edu.au/policy/docs/grading/policy.html

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

Grievance Management Policy http://mq.edu.au/policy/docs/grievance_management/policy.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/

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://informatics.mq.edu.au/help/.

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

Graduate Capabilities

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

- Experience in the use of knowledge of mathematical formalism to explain fundamental concepts and phenomena in electromagnetism
- Experience in applying this knowledge to solve a range of basic problems in modern quantum theory
- Experience in investigating various physical phenomena experimentally, including performing measurements, analysing the data obtained, and writing detailed reports on these investigations

Assessment tasks

- Assignments

- Laboratory reports
- Laboratory logbook

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

- Acquisition of an understanding of the mathematical formalism of classical electromagnetism
- Experience in the use of knowledge of mathematical formalism to explain fundamental concepts and phenomena in electromagnetism
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- Experience in applying this knowledge to solve a range of basic problems in modern quantum theory
- Experience in investigating various physical phenomena experimentally, including performing measurements, analysing the data obtained, and writing detailed reports on these investigations

Assessment tasks

- Assignments
- Laboratory reports
- Laboratory logbook
- Final Examination

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

- Acquisition of an understanding of the mathematical formalism of classical electromagnetism
- Experience in the use of knowledge of mathematical formalism to explain fundamental concepts and phenomena in electromagnetism
- An understanding of the link between the underlying theory of electromagnetism, and everyday phenomena, as well as scientific and engineering applications
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Assessment tasks

- Assignments
- Laboratory reports
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- Final Examination

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

- Acquisition of an understanding of the mathematical formalism of classical electromagnetism
- Experience in the use of knowledge of mathematical formalism to explain fundamental concepts and phenomena in electromagnetism
- An understanding of the link between the underlying theory of electromagnetism, and

everyday phenomena, as well as scientific and engineering applications
- Acquisition of an understanding of the mathematical formalism of quantum mechanics and the physical motivations behind this formalism
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Assessment tasks

- Assignments
- Laboratory reports
- Laboratory logbook
- Final Examination

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

- Acquisition of an understanding of the mathematical formalism of classical electromagnetism
- Experience in the use of knowledge of mathematical formalism to explain fundamental concepts and phenomena in electromagnetism
- An understanding of the link between the underlying theory of electromagnetism, and everyday phenomena, as well as scientific and engineering applications
- Acquisition of an understanding of the mathematical formalism of quantum mechanics and the physical motivations behind this formalism
- Experience in applying this knowledge to solve a range of basic problems in modern quantum theory
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Assessment tasks

- Assignments
- Laboratory reports
- Laboratory logbook
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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

- Experience in applying this knowledge to solve a range of basic problems in modern quantum theory
- Experience in investigating various physical phenomena experimentally, including performing measurements, analysing the data obtained, and writing detailed reports on these investigations

Assessment tasks

- Assignments
- Laboratory reports
- Laboratory logbook
- 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:

Learning outcome

- Experience in the use of knowledge of mathematical formalism to explain fundamental concepts and phenomena in electromagnetism

Assessment tasks

- Assignments

- Laboratory reports
- Laboratory logbook
- Final Examination

Feedback

Student Liaison Committee

The Physics Department values quality teaching and engages in periodic student evaluations of its units, external reviews of its programs and course units, and seeks formal feedback from students via focus groups and the Student Liaison Committee. Please consider being a member of this committee, which meets once during the semester (lunch provided), with the purpose of improving teaching via student feedback. The class will be asked to nominate two students as representatives for the PHYS301 unit on the student liaison committee. This nomination process will be conducted during lectures and the lecturer will forward the names to the Head of Department. The SLC meetings are minuted and student representatives receive copies of the minutes from the two preceding SLC meetings prior to the meeting. An update on the responses that have been made by the department to the feedback obtained at the two preceding SLC meetings are reported by the Head of Department at the beginning of each SLC meeting. These responses are also minuted. The feedback is acted upon in a number of ways mostly initiated via Department of Physics and Astronomy meetings, where decisions on actions are taken.

Requirements in order to complete the unit satisfactorily

To pass the course unit you must:

- achieve a satisfactory standard overall
- achieve a satisfactory standard in each component of the unit, i.e. in electromagnetism, in quantum physics and in the laboratory work (log-book and report writing).

It is strongly recommended you attend all tutorial sesssions. This is a chance for you to ask specific questions you may have pondered outside of lecture and to clear up any conceptual or mathematical confusions.

Standards Expectation

Grading

An aggregate standard number grade (SNG) corresponding to a pass (P) is required to pass this unit.

High Distinction (HD, 85-100%): provides consistent evidence of deep and critical understanding in relation to the learning outcomes. There is substantial originality and insight in identifying, generating and communicating competing arguments, perspectives or problem solving approaches; critical evaluation of problems, their solutions and their implications;

creativity in application.

Distinction (D, 75-84%): provides evidence of integration and evaluation of critical ideas, principles and theories, distinctive insight and ability in applying relevant skills and concepts in relation to learning outcomes. There is demonstration of frequent originality in defining and analysing issues or problems and providing solutions; and the use of means of communication appropriate to the discipline and the audience.

Credit (Cr, 66-74%): provides evidence of learning that goes beyond replication of content knowledge or skills relevant to the learning outcomes. There is demonstration of substantial understanding of fundamental concepts in the field of study and the ability to apply these concepts in a variety of contexts; plus communication of ideas fluently and clearly in terms of the conventions of the discipline.

Pass (P, 50-65%): provides sufficient evidence of the achievement of learning outcomes. There is demonstration of understanding and application of fundamental concepts of the field of study; and communication of information and ideas adequately in terms of the conventions of the discipline. The learning attainment is considered satisfactory or adequate or competent or capable in relation to the specified outcomes.

Fail (F, 0-49%): does not provide evidence of attainment of all learning outcomes. There is missing or partial or superficial or faulty understanding and application of the fundamental concepts in the field of study; and incomplete, confusing or lacking communication of ideas in ways that give little attention to the conventions of the discipline.