PHYS3180

Condensed Matter and Nanoscale Physics

Session 1, Weekday attendance, North Ryde 2020

Department of Physics and Astronomy

Contents

General Information

Unit convenor and teaching staff
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Credit points
10

Prerequisites
(PHYS201 or PHYS2010) and (PHYS202 or PHYS2020) and (MATH235 or MATH2010)

Corequisites
PHYS301 or PHYS3010

Co-badged status

Unit description
Many basic properties of solid crystals can be understood through the periodic nature of the underlying crystal lattice. From the formation of phononic and electronic bands in a solid, to the thermodynamics of a solid, to its interaction with light - all these phenomena can be understood by taking into account the scattering of electrons and lattice vibrations off the periodic crystal lattice. Furthermore, modern (quantum) optics experiments with semiconductor nano-structures employ the very same principles of wave scattering off periodic structures for confining and transporting light in a variety of important technological applications. This course discusses both the fundamental well-established principles of solid-state physics and at the same time explores the fascinating world of modern solid-state experiments, ranging from novel semiconductor devices, to exotic low-dimensional materials such as graphene, to nanoscale quantum optics experiments aimed at taming single light particles.

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: describe how the periodicity of a crystal affects measurable quantities such as

heat capacity or conductivity, demonstrating insight into the concept of crystal momentum and its implications for band structures and scattering experiments.
ULO2: use mathematical descriptions based in real- and momentum-space to solve problems in scattering theory.
ULO3: demonstrate an understanding of basic concepts of statistical physics for explaining some of the phenomenology in condensed-matter physics.
ULO4: discuss the connection between electronic band structure and certain material properties, with specific examples of low-dimensional electronic systems such as semiconductor quantum wells, quantum dots and graphene.
ULO5: apply the ideas developed for naturally-occurring periodic solids to artificially engineered periodic systems, such as photonic crystals, metamaterials and optical lattices for ultracold atoms.
ULO6: carry out condensed matter experiments, demonstrating well-developed experimental skills, python analysis, and proficient scientific writing to generate formalised lab reports.

Assessment Tasks

Coronavirus (COVID-19) Update

Assessment details are no longer provided here as a result of changes due to the Coronavirus (COVID-19) pandemic.

Students should consult iLearn for revised unit information.

Find out more about the Coronavirus (COVID-19) and potential impacts on staff and students

General Assessment Information

The 'estimated time on task' for each assessment item is an estimate of the *additional* time needed to complete each assessment outside of all scheduled learning activities. These estimates assume that you actively engage with all scheduled learning activities *and* spend an additional 31 hours of self-led study during the session.

If you receive special consideration for the final exam, a supplementary exam will be scheduled after the end of the normal 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.

Lab experiments and reports

Students will have to conduct four out of the five following experiments available in the practical part of PHYS308:

- Debye Temperature
- X-ray Diffraction
- Properties of Semiconductors
- Nuclear Magnetic Resonance
- Superconductors

Please note the following points

1. You are required to complete four of the experiments.
2. Students should make a booking for two lab sessions for each experiment they undertake. A booking gives priority provided the students arrive punctually at the start of the laboratory session.
3. A resource folder is available for each project, containing useful background information. These may be taken away from the lab, but must be returned within two weeks for other students to use.
4. You are required to submit a first draft report by the deadline that will be published on iLearn well in advance. The draft 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. The preferred method of submission is a single pdf file (via email to thomas.volz@mq.edu.au with a file name of the form 'LabReportPHYS308_*number_studentname_studentnumber*').
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 copied 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.

Delivery and Resources

Coronavirus (COVID-19) Update

Any references to on-campus delivery below may no longer be relevant due to COVID-19.

Please check here for updated delivery information: https://ask.mq.edu.au/account/pub/display/unit_status

Required textbook covering the first 8 weeks:

Oxford Solid State Basics, by Steven H. Simon.

Note: Lecture materials, additional reading and assignments will be posted to iLearn

Unit Schedule

Coronavirus (COVID-19) Update

The unit schedule/topics and any references to on-campus delivery below may no longer be relevant due to COVID-19. Please consult iLearn for latest details, and check here for updated delivery information: https://ask.mq.edu.au/account/pub/display/unit_status

Lecture content

- week 1: Solid state physics without microscopic structure
- week 2: The 1D solid - vibrations and electrons
- week 3: Crystal Structure and Reciprocal Lattice
- week 4: Wave Scattering by Crystals
- week 5: Phonons in a Solid
- week 6: Electrons in a Solid
- week 7: Energy Bands and Implications
- week 8: Semiconductor Physics + Devices
- week 9: Photonic crystals
- week 10: Metamaterials
- week 11: Low-dimensional semiconductor systems (Quantum dots, quantum wells)
- week 12: Low-dimensional carbon-based systems (Graphene)
- week 13: Current topics in solid-state physics

Labs schedule (location E7B 252)

- week 1: short intro session to give an overview of experiments

- week 2: experiment 1
- week 3: experiment 1
- week 4: free week to write draft report for experiment 1
- week 5: experiment 2
- week 6: experiment 2
- week 7: free week to write final report for experiment 1
- week 8: experiment 3
- week 9: experiment 3
- week 10: free week to write final report for experiment 2 or 3
- week 11: experiment 4
- week 12: experiment 4
- week 13: no experiments.

Schedule of assessable tasks and related materials

Assignments

The assignments will be handed out bi-weekly with the exact dates announced on iLearn.

Labwork

The due dates for draft and final lab reports will be announced in class and on iLearn well in advance.

NOTE:

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***. Once the change has been agreed on, it cannot be moved again. A late penalty applies after the due dates.

You are required to carry out four experiments, each taking no more than two weeks to complete, and to submit reports on two of them according to the deadlines announced in class and on iLearn. These dates are ***not negotiable except in cases of serious illness or misadventure***.

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.)*

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

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 help you improve your marks and take control of your study.

- Getting help with your assignment
- Workshops
- StudyWise
- 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

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.

Changes from Previous Offering

For interested students, there might be the possibility to help set up a new teaching experiment on 2D materials. This option will be discussed in the introductory lab session.