UNSW Course Outline

ZPEM2502 Physics 2B: Electrons, Photons and Matter - 2024

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General Course Information

Course Code : ZPEM2502
Year : 2024
Term : Semester 2
Teaching Period : Z2
Is a multi-term course? : No
Faculty : UNSW Canberra
Academic Unit : UC Science
Delivery Mode : In Person
Delivery Format : Standard
Delivery Location : UNSW Canberra at ADFA
Campus : UNSW Canberra
Study Level : Undergraduate
Units of Credit : 6

Useful Links

Handbook Class Timetable

Course Details & Outcomes

Course Description

The course examines the physics of electromagnetism, quantum mechanics, condensed matter and semiconductors. Electrons are the sources of electric and magnetic fields and fundamentals to our information society. Electrons are considered particles but also have a wave nature, while

electromagnetic waves also have a particle nature, the photon. This particle-wave dualism is unfamiliar to our personal macroscopic experience but is essential for the microscopic world. Electrons and photons also give rise to the functionality of the semiconductor materials that underpin our modern technology. The course includes a laboratory program relating to and supplementing the lecture material.

Course Aims

The aim of the course is to provide students with an understanding of electromagnetism, quantum mechanics, condensed matter and semiconductors, essential physics that underpins our modern technology.

Relationship to Other Courses

This 6 UOC course is a core part of both a Physics major in Science and the Electrical Engineering program. It will be assumed that students have a good working knowledge from the foundation Physics 1 courses, ZPEM1501 and ZPEM1502, and that the student is conversant with Level 1 Mathematics and multivariable calculus from Level 2 Mathematical Tools for Science (ZPEM2302) or Engineering Maths 2A (2309).

Course Learning Outcomes

Course Learning Outcomes
CLO1 : Mastered the key concepts in the topic areas of electromagnetism, quantum physics of electrons and electronic materials, demonstrated by the ability to discuss, describe and explain the topics.
CLO2 : Demonstrate the ability to solve problems relating to electromagnetism and electronic properties of materials.
CLO3 : Develop an appreciation of how the basic Physics in the areas of electronic materials and electromagnetism foster current directions in related research and lead to technological advances.
CLO4 : Apply theoretical knowledge of materials physics and electromagnetism and demonstrate proper scientific methodology when conducting laboratory experiments. In addition develop skills in team work and self-direction.

Course Learning Outcomes	Assessment Item
CLO1 : Mastered the key concepts in the topic areas of electromagnetism, quantum physics of electrons and electronic materials, demonstrated by the ability to discuss, describe and explain the topics.	• 3 class tests • In class quiz • Examination
CLO2 : Demonstrate the ability to solve problems relating to electromagnetism and electronic properties of materials.	• 3 class tests • In class quiz • Examination
CLO3 : Develop an appreciation of how the basic Physics in the areas of electronic materials and electromagnetism foster current directions in related research and lead to technological advances.	• Laboratory program • 3 class tests • Examination
CLO4 : Apply theoretical knowledge of materials physics and electromagnetism and demonstrate proper scientific methodology when conducting laboratory experiments. In addition develop skills in team work and self-direction.	• Laboratory program

Learning and Teaching Technologies

Moodle - Learning Management System | Echo 360

Learning and Teaching in this course

The fundamental physics will be developed in lectures, short demonstrations, short example problems and tutorials, plus video material and short demonstrations. The laboratory program will aide in practical understanding of some aspects of the course materials.

Students are expected to prepare for classes through the study of notes, textbooks, screencasts and other materials available via Moodle, library or internet. Generally, it is a good idea to use multiple sources for studying. The problems either in the notes, or given for tutorial exercises will require either numerical or descriptive answers or explanations. They are specifically designed to consolidate the lecture material, to develop conceptual understanding, to develop problem solving skills, and to help students assess their own progress.

It is anticipated that all components of this course, lectures, tutorials and laboratory, will be delivered in face to face mode. Lectures will be recorded for review by students at later times. The day to day flow of information, both technical and administrative will be largely based on content and activities accessed via Moodle.

Additional Course Information

The microstructure of matter is the result of electronic interactions and quantum phenomena. Electrons, photons and atoms are the main players in this world where wave- particle duality is a strong feature.

This course delves further into the physics of electrons, light and atoms in matter with an emphasis on materials that underpin modern technologies. Some aspects of this physics are best understood within the classical theory of electromagnetism, whereas other aspects require a description drawing from the modern theory of quantum mechanics.

In the first part of the course the physics of electric charges, such as electrons, and that of electric and magnetic fields are discussed within the frame work of classical electromagnetism. The four Maxwell equations are explored and applied. The intrinsic coupling between electric and magnetic fields allows for the existence of electromagnetic waves and thus provides for the classical understanding of light as a wave phenomenon.

In the second part of the course the classical picture of electrons and light is contrasted with their modern description within quantum physics. In particular, the fundamentals of the quantum mechanics of electrons, crystallography and the electronic properties of solid state materials are discussed.

Electrons and photons are central to the course, since they strongly bear out the wave-particle dualism that is unfamiliar to our personal macroscopic experience, but essential for an understanding of the microscopic world. The appreciation of such phenomena prepares students for higher level science and modern electrical engineering applications. Electrons and

photons also give rise to the functionality of the materials that are essential to many modern technologies. Students of this course thus take with them a deep understanding of the fundamentals that permit and limit modern devices. A laboratory program is also included, giving the student opportunity to appreciate the course content from a practical perspective.

Assessments

Assessment Structure

Assessment Item	Weight	Relevant Dates
Laboratory program	20%	Start Date: Not Applicable Due Date: Not Applicable
3 class tests	40%	Start Date: Not Applicable Due Date: Not Applicable
In class quiz	10%	Start Date: 08/10/2024 12:10 PM Due Date: 08/10/2024 01:00 PM
Examination	30%	Start Date: Not Applicable Due Date: Not Applicable

Assessment Details

Laboratory program

Course Learning Outcomes

- CLO3 : Develop an appreciation of how the basic Physics in the areas of electronic materials and electromagnetism foster current directions in related research and lead to technological advances.
- CLO4 : Apply theoretical knowledge of materials physics and electromagnetism and demonstrate proper scientific methodology when conducting laboratory experiments. In addition develop skills in team work and self-direction.

Detailed Assessment Description

The laboratory program includes 5 experiments of 3 hours duration, worth 20% in total. Students are expected to submit detailed lab reports normally due at the conclusion of each class. Requirements and detail in formation on prelab exercises and content will be found in the lab script booklet issued at the start of semester. First script for early start on preparation and auxillary information will be found on Moodle.

Assessment Length

Each student completes 5 lab exercises (3 hours each) per the Physics 2B lab schedule posted on Moodle.

Submission notes

Students should refer to the Physics 2B lab schedule on Moodle for weeks and times of lab attendance. Lab reports due at end of each lab class.

Assessment information

See Moodle for additional information on the lab program.

Assignment submission Turnitin type

Not Applicable

3 class tests

Course Learning Outcomes

- CLO1 : Mastered the key concepts in the topic areas of electromagnetism, quantum physics of electrons and electronic materials, demonstrated by the ability to discuss, describe and explain the topics.
- CLO2 : Demonstrate the ability to solve problems relating to electromagnetism and electronic properties of materials.
- CLO3 : Develop an appreciation of how the basic Physics in the areas of electronic materials and electromagnetism foster current directions in related research and lead to technological advances.

Detailed Assessment Description

Assessment 2 encompasses the collective assessment for the EM (Part1) of the course.
The quizzes (20%) and a class test (20%) combine for a total of 40% for EM theory section assessment.

There will be 6 weekly short EM quizzes generally to be ~10 mins duration and held during the last lecture of the week. These quizzes have a somewhat formative roll, but also best 5 of 6 quiz scores contribute to a total of 20%.

There will be also be a EM class test of 50 mins duration to be held on Tuesday 10 October 2024. This test worth 20% will be paper based and closed book except for permitted aids of a nonprogrammable calculator (Casio FXAu or equivalent) and single double sided A4 sheet of handwritten notes.

Further information for each component will be made available on Moodle.

Assessment Length

EM testing: 6 small weekly quizzes and 50 min class test

Submission notes

quizzes and test submitted at end of each allotted session.

Assessment information

Information on individual quizzes and the test will be promoted on Moodle.

Assignment submission Turnitin type

Not Applicable

In class quiz

Assessment Overview

Not specified

Course Learning Outcomes

- CLO1 : Mastered the key concepts in the topic areas of electromagnetism, quantum physics of electrons and electronic materials, demonstrated by the ability to discuss, describe and explain the topics.
- CLO2 : Demonstrate the ability to solve problems relating to electromagnetism and electronic properties of materials.

Detailed Assessment Description

A class test worth 10% on QPEM (Part II) material will be held in the lecture period on 8 October . This Test will be paper based and 50 minutes in duration. Nonprogrammable calculator (Casio FXAu or equivalent) and single double sided A4 sheet of handwritten notes allowed. Further information will be made available on Moodle.

Assessment Length

50 mins

Submission notes

Hand in at end of test

Assessment information

Further information will be made available on Moodle.

Assignment submission Turnitin type

Not Applicable

Examination

Course Learning Outcomes

- CLO1 : Mastered the key concepts in the topic areas of electromagnetism, quantum physics of electrons and electronic materials, demonstrated by the ability to discuss, describe and explain the topics.
- CLO2 : Demonstrate the ability to solve problems relating to electromagnetism and electronic properties of materials.
- CLO3 : Develop an appreciation of how the basic Physics in the areas of electronic materials and electromagnetism foster current directions in related research and lead to technological advances.

Detailed Assessment Description

2-hour final invigilated exam worth 30% to be held in the examination period. This exam will be paper based, read from paper question sheets and written in exam booklets. Non-programable scientific calculators (Casio FXAU or equiv.) and a single double sided sheet of handwritten notes (plus pens and pencils and rulers) are the allowed aides. Some formulae and data sheets will be provided with the question paper.

The exam will have a focus on the QPEM part of the course assumes knowledge of the content of the EM part as well.

Assessment Length

2 hours

Submission notes

Exam handed in on the day

Assessment information

Additional information on examination logistics, timing and content will be posted on Moodle.

Assignment submission Turnitin type

Not Applicable

General Assessment Information

To provide student feedback some assessment results will be posted in the Moodle gradebook. **Note that all results are provisional and may be subject to change until the final mark is officially confirmed and published by the University**.

The formative quizzes and lab reports are intended to provide students with feedback on their

progress towards further assessments. All assessments will test students' knowledge of the course material, their conceptual understanding of the physics involved and their problem-solving skills.

Note that is prohibited to use any software or service to search for or generate information or answers in this course, either in tests or lab reports. If its use is detected, it will be regarded as serious academic misconduct and subject to the standard penalties, which may include 00FL, suspension and exclusion.

Students who miss assessment tasks must contact the lecturer at the earliest practicable date to discuss the absence.

If the student provides written evidence regarding the reason for the absence (e.g. a medical certificate or a note from a Divisional Officer etc.), via a special consideration application if deemed appropriate. If the reason is acceptable with University guidelines as viewed by lecturer and course convenor, an alternative assessment may be arranged. Otherwise a zero mark will be awarded for that task.

Formal applications for special consideration should be made at myUNSW (My Student Profile tab > My Student Services > Online Services > Special Consideration.

Note that laboratory reports are expected to be written up during the laboratory class. They are routinely due at the end of the class.

Grading Basis

Standard

Requirements to pass course

The assessment for the course has been designed so that an overall mark of 50% or greater indicates that the student has unambiguously demonstrated satisfactory completion of each learning outcome. For this reason, and consistent with the UNSW policy of abolishing the Pass Conceded grade, students who receive less than 50% overall for the course will receive a fail grade.

Course Schedule

Teaching Week/Module	Activity Type	Content
Week 1 : 15 July - 19 July	Blended	Week 1: There will be a course introduction as part of the first lecture, followed by lectures on electromagnetism (EM) and the first formative short quiz during the Thursday lecture. Subsequent weeks through to end of week 6 will follow a similar pattern with EM lectures and short quizzes on Thursdays. The tutorial on the first Monday will be introductory and revisional in nature. Tutorial sin subsequent weeks (up to week 7) on EM will review problems associated with the previous weeks lectures.
Week 7 : 9 September - 13 September	Assessment	Class test 20% on EM in lecture slot on Tuesday 10 September.
	Lecture	Thursday 12 September first QPEM lecture.
Week 8 : 16 September - 20 September	Blended	From week 8 through week 13, QPEM lectures will proceed aided by tutorial work and occasional online formatove questions. In tutorials we will work through assignments 0, then 1 through 4. Details of topics will be found in the QPEM schedule on Moodle.
Week 11 : 7 October - 11 October	Assessment	QPEM class test 8 October.

Attendance Requirements

Students are strongly encouraged to attend all classes and review lecture recordings. Students are indeed expected to attend all lectures, tutorials, laboratory sessions and assessments unless their absence has been approved by the course coordinator. Students who have missed assessments or a laboratory, or expect to miss such a requirement, must inform the course coordinator by email at the earliest practicable date:
In typical circumstances of missed assessments, a formal application for Special Consideration via the prescribed University procedure may be appropriate. Alternative assessment can then be arranged. Otherwise, in the case of absence a mark of zero will be awarded for the assessment. Further information is available under 'assessments'.

General Schedule Information

Course Schedule: Overview

Part I) (EM) Classical electromagnetism: Charges, fields, Maxwell's equations and electromagnetic waves: 15 July to 10 September.

Part II) (QPEM) Electronic properties of materials covering the quantum mechanics of electrons, crystallography and the electronic properties of solid state materials: 12 September to 24 October.

NOTE on laboratory program: Students are required to attend 5 lab classes which are scheduled throughout the semester. Although scheduling is based on the UNSW timetable assigned lab

groups, the definitive schedule is the COURSE LAB TIMETABLE which will be available on Moodle.

Note also that detailed, tabulated form schedules for Parts I and II will be made available on Moodle.

Course Resources

Prescribed Resources

The prescribed textbook for Part I of this course is:

- Fawwaz Ulaby, Eric Michielssen, Umberto Ravaioli, *Fundamentals of Applied Electromagnetics, ed 7 or 8*.

There is no prescribed text for Part II of the course but a number of texts are recommended below.

- Charles Kittel*, Introduction to Solid State Physics,* ed 8.

This is useful reference especially for the crystallography section of the course. Kittel is a text for level 3 Physics; also, a number of copies including older editions which are fine for the purpose are available in the Academy library.

- D. de Cogan, *Solid State Devices - A Quantum Physics Approach*.

This brief book has good outlines of quantum topics and device transport.

- *Physics for Global Scientists and Engineers (2nd Edition)*, by Serway, Jewett, Wilson, Wilson and Rowlands.

Part 2 of the level 1 Physics text has some good introductory material on quantum and solid state physics.

Course information, notes, marks, problems and solutions are made available via

- Moodle
- Handouts - laboratory scripts only

Recommended Resources

There is no prescribed text for Part II of the course but a number of texts are recommended:

- Charles Kittel*, Introduction to Solid State Physics,* ed 8. (or older editions).

This is useful reference especially for the crystallography section of the course. Kittel is a text for level 3 Physics; also, a number of copies including older editions which are fine for the purpose are available in the Academy library.

- D. de Cogan, *Solid State Devices - A Quantum Physics Approach.*

This brief book has good outlines of quantum topics and device transport.

- *Physics for Global Scientists and Engineers (2nd Edition)*, by Serway, Jewett, Wilson, Wilson and Rowlands.

Part 2 of this former level 1 Physics text has some good introductory material on quantum and solid state physics. Again copies are available in the library or the Physics UG labs.

Additional Costs

N/A

Course Evaluation and Development

Student evaluative feedback on this course is gathered via UNSW MyExperience, Science student staff liaison meetings and, most importantly, direct informal discussions between students and staff. Student feedback is taken seriously, and continual improvements are made to the course based in part on such feedback.

Important note: Students are reminded that any feedback provided should be constructive and professional and that they are bound by the Student Code of Conduct Policy.

Staff Details

Position	Name	Email	Location	Phone	Availability	Equitable Learning Services Contact	Primary Contact
Convenor	Wayne Hutchison		Room G22, Building 26	02 5114 5040	Most days during normal working hours; by appointment to be sure.	No	Yes
Lecturer	Darren Goossens		TBA	TBA	Mondays best or by appointment	No	No