UNSW Course Outline

MATS2001 Physical Properties of Materials - 2024

Published on the 08 Feb 2024

General Course Information

Course Code : MATS2001
Year : 2024
Term : Term 1
Teaching Period : T1
Is a multi-term course? : No
Faculty : Faculty of Science
Academic Unit : School of Materials Science & Engineering
Delivery Mode : In Person
Delivery Format : Standard
Delivery Location : Kensington
Campus : Sydney
Study Level : Undergraduate
Units of Credit : 6

Useful Links

Handbook Class Timetable

Course Details & Outcomes

Course Description

-Modern atomic theory: shortfall of classical physics and an introduction to wave mechanics; many-electron atoms and the Pauli exclusion principle; zone and band theories.

-Electrical properties: classification of metals, semiconductors and insulators.

-Thermal properties: heat capacity, thermal expansion, thermal conductivity and thermoelectricity.
-Magnetic properties: diamagnetism, paramagnetism, antiferromagnetism, ferrimagnetism and ferromagnetism; magnetic anisotropy and magnetostriction; magnetic materials and devices.
-Superconductivity and superconducting materials.
-Optical properties.

Course Aims

To generate a sound understanding of the fundamentals of *Modern Electron Theory* needed for understanding various important physical phenomena including electrical, magnetic thermal and optical properties of materials and to show how such properties influence the design and operation of engineering components and devices used in motors, computers, DVD players, televisions, mobile telephones etc

Relationship to Other Courses

Pre-requisite(s): MATH1131 or MATH1141 and MATH1231 or MATH1241 and PHYS1121 or PHYS1131 and CHEM1011 or CHEM1031 or CHEM1811

Course Learning Outcomes

Course Learning Outcomes
CLO1 : Demonstrate enhanced critical thinking, analytical and problem solving skills in materials science and engineering
CLO2 : Show a basic understanding of electron theory and its application to a broad range of materials
CLO3 : Express an understanding of the modern physical principles underlying electrical conduction and magnetism in a range of materials
CLO4 : Display an understanding of the importance of Schrödinger’s equation for calculating electrical resistivity in metals, semiconductors and insulators
CLO5 : Demonstrate an appreciation of a "materials" contributions and importance in electronic systems

Course Learning Outcomes	Assessment Item
CLO1 : Demonstrate enhanced critical thinking, analytical and problem solving skills in materials science and engineering	• Assignment 1 • Mid-term exam • Assignment 2 • Final Exam
CLO2 : Show a basic understanding of electron theory and its application to a broad range of materials	• Assignment 1 • Mid-term exam • Assignment 2 • Final Exam
CLO3 : Express an understanding of the modern physical principles underlying electrical conduction and magnetism in a range of materials	• Assignment 1 • Assignment 2 • Final Exam
CLO4 : Display an understanding of the importance of Schrödinger’s equation for calculating electrical resistivity in metals, semiconductors and insulators	• Assignment 1 • Final Exam
CLO5 : Demonstrate an appreciation of a "materials" contributions and importance in electronic systems	• Final Exam

Learning and Teaching Technologies

Moodle - Learning Management System | Echo 360

Learning and Teaching in this course

The overall aim of this course is to present a fundamental level coverage of electrical, magnetic and optical properties of various materials through introducing modern electron theory. The

lectures will also introduce engineering processes to tune physical properties of materials through optimizing the interaction of electrons in solid state materials used in commercial products such as motors, computers, DVD players, televisions, and mobile telephones etc. Students are actively engaged in the learning process.

It is expected that, in addition to attending classes, students read, write, discuss, and are engaged in solving problems on the electronic properties of materials, and in analysis and evaluation of materials' electron-related properties in the context of modern theories of physics.

- Effective learning is supported by a climate of inquiry where students feel appropriately challenged.

Problems involving electron theory are challenging; students will be given assignments that will motivate deep analysis of various physical phenomena in materials science and engineering.

- Learning is more effective when students' prior experience and knowledge are recognised and built on.

This course is built on prior courses in mathematics, physics and chemistry.

- Students become more engaged in the learning process if they can see the relevance of their studies to professional and disciplinary contexts

Students will be asked to analyse the role of electron theory in understanding various physical phenomena in materials science and how properties such as electrical conduction and magnetism influence the science and engineering of existing and new devices and components.

Lectures: The core concepts will be taught in lectures, students will have access to the lectures notes before class for annotation during the lecture. Students will be engaged in the learning process through class discussions and problem-solving questions independently and working together with partners and groups.

Assignments: Assignments will consolidate the students learning of the core concepts through short answer and problem-solving questions. Students will have the chance to work both collaboratively in class and independently outside of class. Real world examples of the concepts will engage the students in the learning processing by connecting theory to practice.

Additional Course Information

School Office: Room 137, Building E10 School of Materials Science and Engineering
School Website: http://www.materials.unsw.edu.au/

Faculty Office: Robert Webster Building, Room 128

Faculty Website: http://www.science.unsw.edu.au/

Assessments

Assessment Structure

Assessment Item	Weight	Relevant Dates
Assignment 1	20%	Start Date: Not Applicable Due Date: Week 3 and Week 5
Mid-term exam	30%	Start Date: Not Applicable Due Date: Week 7: 25 March - 31 March
Assignment 2	20%	Start Date: 25/03/2024 12:00 AM Due Date: 07/04/2024 12:00 AM Post Date: 06/02/2024 12:00 AM
Final Exam	30%	Start Date: Exam period Due Date: Exam period

Assessment Details

Assignment 1

Assessment Overview

You will be required to undertake calculations involving the application of modern electron theory to topics covered throughout the course including

-The wave nature of electrons

-Electrical conduction in metals, semiconductors and insulators

Feedback will be given two weeks after submission of the assignment and take the form of the marked assignment, comments on how the class performed, and any common areas that were not answered correctly. Additionally, personal feedback and how each student performed may be given. A solution sheet for each assignment, showing the worked answers and relevant comments, will be uploaded onto Moodle two weeks after their submission

Course Learning Outcomes

- CLO1 : Demonstrate enhanced critical thinking, analytical and problem solving skills in materials science and engineering
- CLO2 : Show a basic understanding of electron theory and its application to a broad range of materials
- CLO3 : Express an understanding of the modern physical principles underlying electrical conduction and magnetism in a range of materials
- CLO4 : Display an understanding of the importance of Schrödinger's equation for calculating

electrical resistivity in metals, semiconductors and insulators

Detailed Assessment Description

You will be required to undertake calculations involving the application of modern electron theory to topics covered throughout the course including
-The wave nature of electrons
-Electrical conduction in metals, semiconductors and insulators

Assessment Length

NA

Assignment submission Turnitin type

This assignment is submitted through Turnitin and students can see Turnitin similarity reports.

Mid-term exam

Assessment Overview

The aim of this exam is to assess students' skills in solving problems concerning introductory aspects of electron theory and its application to materials science and engineering (Parts I & II). It will consist of a combination of multiple choice and essay-style questions involving some calculations. Any derivations will assume knowledge of the material rather than memorizing equations with relevant background equations provided.

Feedback: As the mid-term exam is the formal exam for Part 1 of the course, with the content not examinable in Part 2, students will receive their final mark.

Course Learning Outcomes

- CLO1 : Demonstrate enhanced critical thinking, analytical and problem solving skills in materials science and engineering
- CLO2 : Show a basic understanding of electron theory and its application to a broad range of materials

Detailed Assessment Description

The aim of this exam is to assess students' skills in solving problems concerning introductory aspects of electron theory and its application to materials science and engineering (Parts I & II). It will consist of a combination of multiple choice and/or essay-style questions involving some calculations. Any derivations will assume knowledge of the material rather than memorizing equations with relevant background equations provided.

Assessment Length

2 hours

Assignment submission Turnitin type

This is not a Turnitin assignment

Assignment 2

Assessment Overview

You will be required to undertake calculations involving the application of modern electron theory to topics covered throughout the course including

-Magnetic properties of materials

-Thermal properties of materials

-Optical properties of materials

Feedback will be given two weeks after submission of the assignment and take the form of the marked assignment, comments on how the class performed, and any common areas that were not answered correctly. Additionally, personal feedback and how each student performed may be given. A solution sheet for each assignment, showing the worked answers and relevant comments, will be uploaded onto Moodle two weeks after their submission

Course Learning Outcomes

- CLO1 : Demonstrate enhanced critical thinking, analytical and problem solving skills in materials science and engineering
- CLO2 : Show a basic understanding of electron theory and its application to a broad range of materials
- CLO3 : Express an understanding of the modern physical principles underlying electrical conduction and magnetism in a range of materials

Detailed Assessment Description

You will be required to undertake calculations involving the application of modern electron theory to topics covered throughout the course including

-Magnetic properties of materials

-Thermal properties of materials

-Optical properties of materials

Assignment submission Turnitin type

This assignment is submitted through Turnitin and students do not see Turnitin similarity reports.

Final Exam

Assessment Overview

This exam is devoted mainly to Parts III & IV of the course consisting of lectures, nominated reading material and assignments and will include, where appropriate, relevant equations. It will consist of a combination of essay-style answers and calculations. Any derivations will assume knowledge of the material rather than memorizing equations with relevant background equations provided.

Feedback: Students will receive their final mark.

Course Learning Outcomes

- CLO1 : Demonstrate enhanced critical thinking, analytical and problem solving skills in materials science and engineering
- CLO2 : Show a basic understanding of electron theory and its application to a broad range of materials
- CLO3 : Express an understanding of the modern physical principles underlying electrical conduction and magnetism in a range of materials
- CLO4 : Display an understanding of the importance of Schrödinger's equation for calculating electrical resistivity in metals, semiconductors and insulators
- CLO5 : Demonstrate an appreciation of a "materials" contributions and importance in electronic systems

Detailed Assessment Description

This exam is devoted mainly to Parts III & IV of the course consisting of lectures, nominated reading material and assignments and will include, where appropriate, relevant equations. It will consist of a combination of essay-style answers and calculations. Any derivations will assume knowledge of the material rather than memorizing equations with relevant background equations provided.

Assessment Length

2 hours

Assignment submission Turnitin type

Not Applicable

General Assessment Information

- Unless otherwise specified in the task criteria, all assignments must be handed in during class to the lecturer prior to or on the due date for submission
- Assignments submitted after the due date for submission will receive a 10% of maximum grade penalty for every day late, or part thereof.

- UNSW operates under a Fit to Sit/ Submit rule for all assessments. If a student wishes to submit an application for special consideration for an exam or assessment, the application must be submitted prior to the start of the exam or before an assessment is submitted. If a student sits the exam/ submits an assignment, they are declaring themselves well enough to do so. Information on this process can be found here: https://student.unsw.edu.au/special-consideration. Medical certificates or other appropriate documents must be included. Students should also advise the lecturer of the situation.
- Students who have a disability that requires some adjustment in their teaching or learning environment are encouraged to discuss their study needs with the course coordinator prior to, or at the commencement of, their course, or with the Equity Officer (Disability) in the Equity and Diversity Unit: https://student.unsw.edu.au/disability. Early notification is essential to enable any necessary adjustments to be made.
- Inspera is the proposed system to manage digital midterm and final exam assessments for this course.

- **Short Extensions:**
  The School of Materials Science and Engineering has reviewed its range of assignments and projects to determine their suitability for automatic short extensions as set out by the UNSW Short Extension Policy. After consultation with teaching staff and examination of our course offerings we consider our current deadline structures already accommodate the possibility of unexpected circumstances that may lead students to require additional days for submission. Consequently, the School does not offer the Short Extension provision in its MATS courses but students, if needed, students can apply for formal Special Consideration via the usual procedure.

Grading Basis

Standard

Course Schedule

Teaching Week/Module	Activity Type	Content
Week 1 : 12 February - 18 February	Lecture	• Introduction to the course • Shortcomings of classical physics • Particle and wave nature of matter • Introduction to the Schrödinger equation • The Schrödinger equation-model of the hydrogen atom • Quantum description of the atom
Week 2 : 19 February - 25 February	Lecture	• The Schrödinger equation • Handling multiple electrons in a crystal • Methods of describing electron energy levels in crystals
Week 3 : 26 February - 3 March	Lecture	• Electrical conduction in solids • Breakdown of the classical theory of conduction • Quantum model of electrical conduction • Intrinsic semiconducting elements • Electrical conduction of intrinsic semiconductors
	Assessment	Assignment 1 due
Week 4 : 4 March - 10 March	Lecture	• The combined role of the band gap and temperature on conductivity • Simple intrinsic semiconductor devices • Extrinsic semiconductors • Introduction to band-gap engineering
Week 5 : 11 March - 17 March	Lecture	• Physics of the p-n junction • Basic semiconducting devices • Review of Parts I and II
	Assessment	Assignment 2 due
Week 7 : 25 March - 31 March	Lecture	• Basic concepts of magnetism • Types of magnetic behaviour • Modern theories of ferri/ferromagnetism • Magnetic domains and Bloch walls
	Assessment	Mid-exam
Week 8 : 1 April - 7 April	Lecture	• Basic ferromagnetic and ferrimagnetic devices • Superconductivity • Types of superconducting materials • BCS theory of superconductivity • Superconducting devices
	Assessment	Assignment 3 due
Week 9 : 8 April - 14 April	Lecture	• Thermal properties of materials • Thermal expansion • Thermoelectricity and the Seebeck effect • Optical properties of materials
Week 10 : 15 April - 21 April	Lecture	• Optical devices
	Assessment	Assignment 4 due

Attendance Requirements

Students are strongly encouraged to attend all classes and review lecture recordings.

General Schedule Information

This course consists of 48 hours of class contact hours. You are expected to take an additional 98 hours of non-class contact hours to complete assessments, readings and exam preparation spread over the term.

Course Resources

Prescribed Resources

Preferred textbook:

- Electronic Properties of Materials, Hummel, Rolf E. 4th ed. Springer. ISBN: 978-1441981639

Other suitable books at the elementary level

- The Structure and Properties of Materials: Volume IV – Electronic Properties: R.M. Rose, L.A. Shepard and J. Wulff, John Wiley and Sons, 1966.
- Lectures on the Electrical Properties of Materials: L. Solymar and D. Walsh, Oxford, 1988.
- An Introduction to the Electron Theory of Solids: J. Stringer, Pergamon, 1967.
- Introduction to the Modern Theory of Metals: A. Cottrell, Institute of Metals, London, 1988.
- Physics of Solids: C.A. Wert and R.M. Thompson, McGraw-Hill, 1964.
- Introduction to Solid State Physics: C. Kittel, John Wiley and Sons, 1986.
- Electronic Properties of Crystalline Solids: R.H. Bube, Academic Press, New York, 1974.
- Solid State Theory in Metallurgy: P. Wilkes, Cambridge University Press, 1973.
- Solid State Electronic Devices: B.G. Streetman, Prentice-Hall, 1980.

Magnetic Materials: R.S. Tebble and D.J. Craik, Wiley Interscience, 1969

Recommended Resources

Preferred textbook:

- Electronic Properties of Materials, Hummel, Rolf E. 4th ed. Springer. ISBN: 978-1441981639

Other suitable books at the elementary level

- The Structure and Properties of Materials: Volume IV – Electronic Properties: R.M. Rose, L.A. Shepard and J. Wulff, John Wiley and Sons, 1966.
- Lectures on the Electrical Properties of Materials: L. Solymar and D. Walsh, Oxford, 1988.
- An Introduction to the Electron Theory of Solids: J. Stringer, Pergamon, 1967.
- Introduction to the Modern Theory of Metals: A. Cottrell, Institute of Metals, London, 1988.
- Physics of Solids: C.A. Wert and R.M. Thompson, McGraw-Hill, 1964.
- Introduction to Solid State Physics: C. Kittel, John Wiley and Sons, 1986.
- Electronic Properties of Crystalline Solids: R.H. Bube, Academic Press, New York, 1974.
- Solid State Theory in Metallurgy: P. Wilkes, Cambridge University Press, 1973.
- Solid State Electronic Devices: B.G. Streetman, Prentice-Hall, 1980.
- Magnetic Materials: R.S. Tebble and D.J. Craik, Wiley Interscience, 1969.

Additional Costs

NA

Course Evaluation and Development

Assignments: Feedback will be given two weeks after submission of the assignment and take the form of the marked assignment, comments on how the class performed, and any common areas that were not answered correctly. Additionally, personal feedback and how each student performed may be given. A solution sheet for each assignment, showing the worked answers and relevant comments, will be uploaded onto Moodle two weeks after their submission.

Mid-term exam: As the mid-term exam is the formal exam for Part 1 and 2 of the course, with the content not examinable in Part 3, students will receive their final mark.

Final exam: Students will receive their final mark.

Staff Details

Position	Name	Email	Location	Phone	Availability	Equitable Learning Services Contact	Primary Contact
Convenor	Dewei Chu		Room 244, Building E10	92855090	By appointment	Yes	Yes
Lecturer	John Daniels		Room 338 Materials Science and Engineering (Bldg E10)	9385 5607	By appointment	No	No

Other Useful Information

Academic Information

Upon your enrolment at UNSW, you share responsibility with us for maintaining a safe, harmonious and tolerant University environment.

You are required to:

- Comply with the University's conditions of enrolment.
- Act responsibly, ethically, safely and with integrity.
- Observe standards of equity and respect in dealing with every member of the UNSW community.
- Engage in lawful behaviour.
- Use and care for University resources in a responsible and appropriate manner.
- Maintain the University's reputation and good standing.

For more information, visit the UNSW Student Code of Conduct Website.

Academic Honesty and Plagarism

Referencing is a way of acknowledging the sources of information that you use to research your assignments. You need to provide a reference whenever you draw on someone else's words, ideas or research. Not referencing other people's work can constitute plagiarism.
Further information about referencing styles can be located at https://student.unsw.edu.au/referencing

Academic integrity is fundamental to success at university. Academic integrity can be defined as a commitment to six fundamental values in academic pursuits: honesty, trust, fairness, respect, responsibility and courage. At UNSW, this means that your work must be your own, and others' ideas should be appropriately acknowledged. If you don't follow these rules, plagiarism may be detected in your work.
Further information about academic integrity, plagiarism and the use of AI in assessments can be located at:

- The Current Students site,
- The ELISE training site, and
- The Use of AI for assessments site.

The Student Conduct and Integrity Unit provides further resources to assist you to understand your conduct obligations as a student: https://student.unsw.edu.au/conduct

Submission of Assessment Tasks

Penalty for Late Submissions
UNSW has a standard late submission penalty of:

- 5% per day,
- for all assessments where a penalty applies,
- capped at five days (120 hours) from the assessment deadline, after which a student cannot submit an assessment, and
- no permitted variation.

Any variations to the above will be explicitly stated in the Course Outline for a given course or assessment task.

Students are expected to manage their time to meet deadlines and to request extensions as early as possible before the deadline.

Special Consideration

If circumstances prevent you from attending/completing an assessment task, you must officially apply for special consideration, usually within 3 days of the sitting date/due date. You can apply by logging onto myUNSW and following the link in the My Student Profile Tab. Medical documentation or other documentation explaining your absence must be submitted with your application. Once your application has been assessed, you will be contacted via your student email address to be advised of the official outcome and any actions that need to be taken from there. For more information about special consideration, please visit: https://student.unsw.edu.au/special-consideration

Important note: UNSW has a "fit to sit/submit" rule, which means that if you sit an exam or submit a piece of assessment, you are declaring yourself fit to do so and cannot later apply for Special Consideration. This is to ensure that if you feel unwell or are faced with significant circumstances beyond your control that affect your ability to study, you do not sit an examination or submit an assessment that does not reflect your best performance. Instead, you should apply for Special Consideration as soon as you realise you are not well enough or are otherwise unable to sit or submit an assessment.

Faculty-specific Information

Additional support for students

- The Current Students Gateway
- Student Support
- Academic Skills and Support
- Student Wellbeing, Health and Safety
- Equitable Learning Services
- UNSW IT Service Centre
- Science EDI Student Initiatives, Offerings and Guidelines