Course Outline

MATS2001

Physical Properties of Materials

Materials Science and Engineering

Science

T1, 2022

1. Staff

Position	Name	Email	Consultation times and locations	Contact Details
Course Convenor/ Lecturer	Professor Dewei Chu	d.chu@unsw.edu.au	Room 244 Materials Science and Engineering (Bldg E10) by appointment	Phone: 9385 5090
Lecturer	Associate Professor John Daniels	j.daniels@unsw.edu.au	Room 338 Materials Science and Engineering (Bldg E10) by appointment	Phone: 9385 5607

2. Course information

Units of credit: 6

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

Timetabling website: https://timetable.unsw.edu.au/2023/MATS2001.html

Teaching times and locations:

	Lecture	Lecture	Lecture
Day	Monday	Wednesday	Friday
Location	Central Lecture Block 1 (K-E19-G02)	Central Lecture Block 1 (K-E19-G02)	Central Lecture Block 1 (K-E19-G02)
Time	16:00-18:00	10:00-12:00	15:00-17:00
Weeks	1,3,5,7,9,10	1-10	1-10

2.1 Course summary

-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.

2.2 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

2.3 Course learning outcomes (CLO)

At the successful completion of this course you (the student) should be able to:

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

2.4 Relationship between course and program learning outcomes and assessments

Course Learning Outcome (CLO)	**LO Statement**	**Program Learning Outcome (PLO)**	**Related Tasks & Assessment**
CLO 1	Demonstrate enhanced critical thinking...	1.3, 1.4, 3.2, 3.3 & 3.4	1, 2, 3 & 4
CLO 2	Show a basic understanding…	1.3, 1.4, 3.2, 3.3 & 3.4	1, 2, 3 & 4
CLO 3	Express an understanding…	1.3, 1.4, 3.2, 3.3 & 3.4	1 & 3
CLO 4	Display an understanding…	1.3, 1.4, 3.2, 3.3 & 3.4	1 & 4
CLO 5	Demonstrate an appreciation…	1.3, 1.4, 3.2, 3.3 & 3.4	4

3. Strategies and approaches to learning

3.1 Learning and teaching activities

(Based on UNSW Learning Guidelines)

Core concepts, theories and approaches to numerous problems concerning the electron theory of solids will be covered in lectures. Examples will be provided to demonstrate the use of wave mechanics in materials science and engineering. A number of tutorial classes will be conducted throughout the course to enhance problem-solving skills with incomplete problems given as homework.
It is expected that students attending classes are prepared for discussion.
Teaching material, including the course outline, assignments, examples of solutions of problems and course announcements are available on Moodle.

- 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.

3.2 Expectations of students

- Students must attend at least 80% of all classes with the expectation that students only miss classes due to illness or unforeseen circumstances
- Students must read through lecture notes and lab sheets prior to class
- During class, students are expected to engage actively in class discussions

- Students should work through lecture, tutorial and textbook questions
- Students should complete all assessment tasks and submit them on time
- Students are expected to participate in online discussions through the Moodle page

4. Course schedule and structure

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.

Week	Topics	Activity
1-2	**PART I- Fundamentals of electron theory**	
1	• 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	
2	• The Schrödinger equation • Handling multiple electrons in a crystal • Methods of describing electron energy levels in crystals	
3-5	**PART II- Electrical properties of materials**	
3	• Electrical conduction in solids • Breakdown of the classical theory of conduction • Quantum model of electrical conduction • Intrinsic semiconducting elements • Electrical conduction of intrinsic semiconductors	Assignment 1
4	• The combined role of the band gap and temperature on conductivity • Simple intrinsic semiconductor devices • Extrinsic semiconductors • Introduction to band-gap engineering	
5	• Physics of the p-n junction • Basic semiconducting devices • Review of Parts I and II	Assignment 2
7	• Mid-session Quiz	Mid-term exam
7-8	**Part III- Electromagnetic properties of materials**	
7	• Basic concepts of magnetism • Types of magnetic behaviour • Modern theories of ferri/ferromagnetism • Magnetic domains and Bloch walls	
8	• Basic ferromagnetic and ferrimagnetic devices	Assignment 3

	• Superconductivity • Types of superconducting materials • BCS theory of superconductivity • Superconducting devices	
9-10	Part IV- Thermal and optical properties of materials	
9	• Thermal properties of materials • Thermal expansion • Thermoelectricity and the Seebeck effect • Optical properties of materials	
10	• Optical devices	Assignment 4

5. Assessment

5.1 Assessment tasks

Assessment task	Description	Weight	Due date
Assignment 1,2:	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	20%	Assignment 1: Week 3 Assignment 2: Week 5
Mid-term exam:	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.	30%	Week 7
Assignment 3, 4:	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	20%	Assignment 3: Week 8 Assignment 4: Week 10
Final exam:	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.	30%	End of term exam period

Further information

UNSW grading system: https://student.unsw.edu.au/grades

UNSW assessment policy: https://student.unsw.edu.au/assessment

5.2 Assessment criteria and standards

Each assignment and exam question will be graded on a rating scale of (1)-(5), where the highest rating (1) denotes: (i) a correct mathematical solution to the problem together with a logical 2-5 line written explanation of the meaning of the result, or (ii) a thorough written explanation of the question if it is an essay-type one (full marks), through to (5), which indicates that no attempt was made to answer the question (no marks). This rating is converted to the value of the mark for each question. All assessment criteria and standards are available on the course Moodle page.

5.3 Submission of assessment tasks

- 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.

5.4. Feedback on assessment

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 of the course, with the content not examinable in Part 2, students will receive their final mark.

Final exam: Students will receive their final mark.

6. Academic integrity, referencing and plagiarism

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. If you compare a calculated result in an assignment with an experimental value taken from the literature, please reference the source: Authors, publication & date.

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.[1] 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.

[1] International Center for Academic Integrity, 'The Fundamental Values of Academic Integrity', T. Fishman (ed), Clemson University, 2013.

Further information about academic integrity and **plagiarism** can be located at:

- The *Current Students* site https://student.unsw.edu.au/plagiarism, and
- The *ELISE* training site http://subjectguides.library.unsw.edu.au/elise/presenting

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

7. Readings and 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.

8. Administrative matters

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/

9. Additional support for students

- The Current Students Gateway: https://student.unsw.edu.au/
- Academic Skills and Support: https://student.unsw.edu.au/academic-skills
- Student Wellbeing, Health and Safety: https://student.unsw.edu.au/wellbeing
- Disability Support Services: https://student.unsw.edu.au/disability-services
- UNSW IT Service Centre: https://www.it.unsw.edu.au/students/index.html
- Assessment Implementation Procedure: https://www.gs.unsw.edu.au/policy/documents/assessmentimplementationprocedure.pdf